Dissertation on

ANATOMY OF THE BRONCHO PULMONARY SEGMENTS

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CERTIFICATE

This is to certify that the dissertation on "**ANATOMY OF THE BRONCHO PULMONARY SEGMENTS"** is a bonafide work, carried out in the Upgraded Institute of Anatomy, Madras Medical College, Chennai - 600 003, during 2004-2007 by **Dr.A.SENTHAMIL SELVI**, under my supervision and guidance in partial fulfillment of the regulation laid down by the Tamil Nadu Dr.M.G.R.Medical University, for the M.S., Anatomy, Branch-V Degree Examination to be held in March 2007.

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CONTENTS

INTRODUCTION

The exchange of respiratory gases is a basic essential of the life process, even in its states of suspension , as in seeds or spores, in hibernation or aestivation, when respiration may be greatly diminished but not wholly abolished.

The respiratory adaptations assume a dual nature – the transport of respiratory gases and the development , often deep within the animal's body , of specialized areas for gaseous exchange. The breathing tubes or tracheal system of the Arthropoda are an example of the former , and it is worthy of note that in the chitinous rings maintaining the patency of such tracheoles there is a structural theme which recurs in all vertebrates

In land vertebrates the lung is almost always a bilateral structure and the interior of these paired pharyngeal diverticula , served by a single air-tube the trachea , becomes highly complicated by folding of its epithelium to increase the area of interchange at which blood is exposed to inspired air.

The specialization into a tracheo - bronchial 'tree' of air – transporting tubes and the terminal array of thin - walled alveolar sacs , where gas exchanges occur , is universal in land vertebrates.

Although the tubes acquire the ability to enter their caliber by contraction or relaxation of the non – striated muscle in their walls , it is in the alveoli that the main volumetric changes of inspiration and expiration occur.

There is considerable variation in the dimensional characteristics of alveoli and bronchi including the pattern of branching of the bronchi and lobulation of the lungs . However , this pattern displays considerable constancy in its major features ; and recognition of this in man has proved to be especially valuable in problems of diagnosis and surgical treatment of pulmonary disorders.

Until recent decades , the anatomy of the lungs was little understood and seemingly less important subject . With the development of the radiographic and endoscopic techniques , and the advancement of pulmonary surgery , detailed anatomic knowledge of the lungs became a necessity.

The prevailing pattern of origin, branching and distribution of the bronchi and the variations are apt to be of particular interest but for the physicians and the surgeons.

The detailed anatomy of the thorax [Fig.No.1 (i to iv)] has become of interest to the surgeon only within relatively recent years , when it is realized that the first successful pneumonectomy was carried out as recently as 1931 [Nissen] , and that-since that time the dread of entering the thoracic cavity for surgical intervention has been so minimized that operation upon the nervous system here , the lungs , the esophagus , the great vessels and even the heart have become almost routine , the enormous and rapid strides in thoracic surgery become literally astounding.

As usual , the increased accessibility to the surgeon has resulted in the need for more accurate and detailed knowledge of the anatomy .

The parts of the respiratory system are the air passages , the larynx , the trachea , the bronchi and their divisions , together with the two lungs covered by a serous membrane – the pleura . The lungs consist of the intra - pulmonary bronchi with the respiratory tissue proper, the respiratory bronchioles and air saccules.

Hence, a saturated knowledge about the skeletal structure of the broncho-pulmonary segments is required in the surgical treatment of certain pulmonary diseases.

Having knowledge of models of the bronchial tree branching–is of a special interest for clinical and surgical pulmonology–because the hemilobectomy, segmentectomy and sub - segmentectomy are always determined by intralobar, intra-segmental and intra-sub segmental bronchial ramification .

Also , the knowledge of the position of the fissures of the lungs is necessary for the appreciation of lobar anatomy and thus locating the bronco - pulmonary segments.

AIM OF THE STUDY

The development of the concept of the broncho - pulmonary segments as a surgical unit is a natural consequence of the skill of the thoracic surgeon and his qualms at sacrificing unnecessarily the healthy pulmonary tissue by lobectomy , when only a small segment of the lobe is diseased.

The pioneer work of **Churchill & Belsey** , reported in 1939 , on the removal of pulmonary tissue along segmental planes has since that time led to the removal of the most of the broncho - pulmonary segments either alone or in combination with other segments , with consequent sparing of the healthy tissue within the lobe .

Hence, there is a longing necessity for the anatomy of the tracheo - bronchial tree, to be updated for the surgery of the broncho - pulmonary segments which must be regarded as a landmark in our modern knowledge .

Congenital lesions of the lung encompass a wide array of fascinating bronchial and pulmonary anomalies that present clinically in infancy , childhood and young adulthood , require a high index of suspicion and careful diagnosis for optimal therapeutic intervention , which can save the life of the neonate or infant . At the other end of the chronologic spectrum , the surgical treatment of elderly patients with emphysematous lung disease requires the same precision of diagnosis and treatment .

As the surgical techniques for adult pulmonary diseases were developed , they were applied to the infant and pediatric populations with life threatening congenital abnormalities with gratifying results , thus setting the standards for the knowledge of the anatomical structure of the bronchial tree and broncho - pulmonary segments .

As the broncho - pulmonary segments are roughly pyramidal in shape and are separated from one another by the connective tissue septa, these subunits can be defined radiologically and can be removed surgically without significant hemorrhage or air leakage .

The knowledge of the broncho - pulmonary segments is useful in :

a) Bronchoscopic procedures, [Fig.No.4]

b) Deciding suitable positions to be adopted by the patients in case of the lung abscess.

c) Surgical resection of the broncho - pulmonary segments when indicated in diseased,

d) Précising interpretation of the radiographs and other medical images of the lungs, and

e) Determining the nature of the lesion as well as its situation .

As per the definition , the concept of broncho -pulmonary segments as anatomical units is not new , and is indeed quite obvious : “ just as the lobes constitute major segments of the lung , with their own bronchial ,

arterial , and venous supply, so do the bronchi within a lobe [Fig.No.2 and 3] branch and rebranch to supply smaller and smaller segments of tissue , any one of which might be regarded as a broncho - pulmonary segment".

Hence, here the study of the branching pattern of the broncho - pulmonary tree was undertaken .

EMBRYOLOGY

The field of embryology is rich in important investigators and scientific breakthroughs, and the history of pulmonary embryology is no exception.

Currently, we have a very clear picture of pulmonary development in the human. Although much of the focuses are on prenatal pulmonary development, it is important to note that pulmonary morphogenesis and differentiation don't end at birth. Significant alveolar remodeling and growth occur during childhood. The development of the lung in humans certainly extends to the age of 8 years and may continue beyond this mark in some individuals.

A knowledge of normal developmental anatomy facilitates the classification and understanding of the various congenital lesions of the lung that develop in the neonate, infant or childhood.

Important contributions to human pulmonary embryology have been made by a number of individuals. In 1936, Dubrenil devised the first system of nomenclature for pulmonary development. Concurrently, Congdon, as well as Streeter [1945a, 1945b, 1948, 1951], working at the Carnegie Institute during the first half of the 20th century, were able to document systematically pulmonary development in relation to development of the fetus as a whole. Over the next twenty years, several embryologists, including Loosli and Potter [1951], Bucher and Reid [1961], Boyden and Tompsett [1965], and Hislop and colleagues [1972], made major contributions specific to pulmonary development. We are particularly indebted to Boyden for advancing the technique of wax modeling of the bronchial tree and vasculature. More

recently, Campiche and associates [1963] and Thurlbeck [1988] have made important advances in related fields.

The respiratory system arises as a median ventral diverticulum of the foregut called the tracheo bronchial groove. This groove may represent the fused pharyngeal pouches, indicating the possible evolutionary origin of the terrestrial respiratory apparatus. The ventral diverticulum gives origin to the lining epithelia, and the associated glands, of the larynx, trachea and bronchi, and to respiratory epithelium of the alveoli. The mesenchymal constituents of these structures i.e. the cartilage, muscle, elastic connective tissue, blood vessels and lymphatics, arise from the splanchnic mesoderm on the ventral surface of the foregut, into which the respiratory diverticulum and its subsequent subdivisions extend.

The respiratory diverticulum [Fig.No.5] first appears in embryos of about twenty five somites [middle of the fourth week] immediately caudal to the hypo branchial eminence. Shortly after its appearance, the foregut caudal to it [esophagus] lengthens rapidly and shows a narrowed lumen. A median longitudinal groove develops, bounded on each side by a ridge. With further growth the groove deepens and the caudal portions of the ridges fuse, separating the caudal part of the groove from the esophagus. The fusion of the ridges gradually extends cranially so that the respiratory primordium becomes more and more separated from the foregut until only a small communication remains just behind the hypobranchial eminence. This communication is the primitive laryngeal aditus. If the fusion is incomplete, abnormal openings may be left between the larynx or trachea and the esophagus. While this separation

is occurring, the caudal extremity of the diverticulum divides dichotomously and becomes bi-lobed, each lobe forming in later development, the endodermal tissue of a primary bronchus and a lung. The median, undivided portion of the diverticulum becomes the trachea and cranially the laryngeal cavity.

TRACHEA, BRONCHI, LUNGS.

After its separation from esophagus and pharynx, the tracheal portion of the respiratory tract grows rapidly. Cartilaginous rings develop in its mesoderm and cartilage reaches the lobar and segmental bronchi in the eleventh and twelfth week respectively. Failure of the development of the bronchial cartilage may result in congenital emphysema.

Each terminal lobe of the endodermal out growth, together with the surrounding splanchnopleuric mesenchyme, constitutes a lung bud from which all the tissues of the corresponding lung and bronchial tree will be derived. [Fig.No.6] Initially the endodermal lung buds are symmetrically situated and represent the two main bronchi. Their blind extremities, which are actively proliferating, represent the potential bronchial tree and respiratory epithelium. Soon, however, the lung buds become asymmetrical, the left one lying more transversely than the right. Each blind endodermal bud gives origin to a monopodial ventral diverticulum and, shortly afterwards [15 mm stage], the right endodermal bud gives origin to a cranio dorsal, monopoidal diverticulum which later becomes the upper lobe bronchus. Thus, at this stage, the right lung bud possesses three bronchial tubes, while the left has only two. These endodermal tubes, which represent the principal branches of the adult main, or stem bronchi, together with the lung bud mesenchyme surrounding them, give

origin to the definitive lobes of the adult lungs. In subsequent development the stem bronchi divide dichotomously until some eighteen generations of sub divisions, many unequal, are produced by the time of birth [Fig.No.7]. Occasional monopodial branchings of the stem bronchi account for the accessory bronchi and lobes [e.g. infra cardiac] often found in the adult lungs.

As the bronchial tree increases in size and extent, the surrounding lung mesenchyme becomes partially subdivided by formation of furrows between the lobes formed by the primary branches of the bronchi. These indentations are lined by the mesothelium [visceral layer of pleura] covering each lung bud. The lungs extend so rapidly into the enlarging pleural cavities that in the early fetus, the adult lobes and fissures are already definitely established. The mesenchyme condensed around the endodermal tubes gives origin to the bronchial musculature and cartilaginous rings to the pulmonary connective tissue. In this tissue capillary loops derived from the pulmonary arteries differentiate. The further developments of the pleural cavities occur then.

PULMONARY ALVEOLI & RESPIRATORY EPITHELIUM

For the greater part of fetal life the lining of all the branches of the bronchial tree is a continuous cuboidal epithelium of endodermal origin. Cilia appear on the epithelial cells of the trachea and main bronchi in the fifth month and spread progressively toward the periphery of the bronchial tree. In the sixth and seventh months of fetal life the cells of the terminal bronchi are low cubiodal and they remain so until birth. The development of the lungs can be divided into three stages:

(a) a glandular period up to the fourth month of gestation, during which the bronchial divisions are established;

(b) a canalicular period, fourth to sixth months of gestation, during which the respiratory portion is delineated; and

(c) A period of alveolar formation, sixth month to full term.

In glandular period the lung consists of a loose mass of connective tissue with an actively proliferating central lobular mass, composed of acini the walls of which are lined with tall columnar epithelial cells with dark nuclei. During the canalicular period the lung becomes highly vascular and the epithelial cells of the developing bronchi become cuboidal. In the alveolar period the capillary loops establish intimate relations with the developing alveoli and the ductal epithelial cells of the acini become flattened. By the seventh month of the fetal life the capillaries are sufficiently well developed to support extra-uterine existence and a premature infant of this age is then viable. The definitive alveoli are derived by the subdivision of larger saccular spaces. It has been demonstrated that the terminal bronchioles don’t cease division at birth and that new bronchioles and alveoli are produced post natally for six or seven further generations of divisions.

Mucus is secreted from the surface epithelium by goblet cells which first appear at 13 weeks and by tubulo – acinar glands in the sub mucosa which first appear in the trachea as epithelial invaginations at the eighth week and in the bronchi at the twelfth to thirteenth week.

Aeration of the lung is not the inflation of a collapsed, empty organ but the rapid replacement of intra – alveolar fluid by air.

Much of the current work on lung development is focused on signaling pathways and the role of growth factors in morphogenesis and cyto differentiation.

This is heterogeneous expression of signaling pathways, growth factors, and their receptors along the bronchial tree. Growth factor, including epidermal growth factor [EGF], transforming growth factor – ß$_1$ [TGFB$_1$], endodermal bone morphogenic protein 4 [BMP – 4], and mesenchymal fibroblast growth factor – 10 [FGF – 10], interact with these pathways to effect both proximal and distal cell differentiation, as shown by Chinoy [1998], Minco [1995], Bellusci and co – workers [1996, 1997]. The release of vascular endothelial growth factor [VEGF] by respiratory epithelium has been identified as a key factor in the development of the capillary network that forms the air – blood barrier by Ferrara & associates [1991]. These are but a few of the countless interactions that lead to the development of a functional and mature lung.

Both paediatric and adult patients with pulmonary parenchymal injury may benefit from research aimed at lung regeneration and healing. Finally, mutations in the genes that normally regulate lung development may be implicated in the formation of pulmonary malignancy.

REVIEW OF LITERATURE

Deve, M.F., [1900][38] , observed a fissure on the diaphragmatic surface of the lower lobe of right lung, sharply curved towards the vertebral border of the lung from a beginning just anterior to the pulmonary ligament; which defined the 'cardiac lobe' or medial basal segment of the lung. He identified this fissure in 35 % of cases.

He also reported a partial fissure between the superior and the basal segments of the lower lobes, as occurring 40 times on the right and 14 on the left in 180 infants.

GILLASPIE, C., MILLER,L.I., AND BASKIN, M., [1916][47], has told that anomalies of lobulation of the lungs may be produced by fusion of adjacent lobes to obliterate a fissure, or by the occurrence of abnormal fissures, or by the aplasia or agenesis of a part of a lung.

The occasional lack of normal development of the right horizontal fissure, may result in a right lung composed of two rather than three lobes.

HARVEY ERNEST JORDAN AND JAMES ERNEST KINDRED [1937][11] University of Virginia, state that eparterial bronchus on left side will produce three left pulmonary lobes and the eparterial bronchial ramus on the right side may arise as a branch of the trachea which are anomalous conditions in man.

CHURCHILL, E.D., ET AL., [1940][30] emphasized that bronchiectasis typically has a segmental distribution affecting the lingular lobe and the basal

segments of the lower lobe on the left, the middle lobe and the basal segments of the lower lobe on the right.

LESLIE BRAINERD AREY, [1941][39], in his manual of embryology, explains that the apical bronchus of the right upper lobe is also called the eparterial bronchus because it alone lies upon the pulmonary artery i.e., originally dorsal to but later as the heart descends cranial to the pulmonary artery. The left upper lobe seems to contain a bronchial branch that is the equivalent of the entire apical bud on the right side. Since, however, this branch remains small and never induces the formation of a separate lobe, the upper lobe of the left lung is thus homologous to both the upper and middle lobes on the right side. On stating the variations, has told that rarely there is an eparterial lobe on the left.

FERGUSON AND NEUHAUSEN [1944][43] have reported a patient with only a right upper lobe bronchus, with the absence of a middle lobe bronchus at bronchoscopy.

BOYDEN, E. A., [1945][20] has said that the two sub-segmental bronchi that belonged to the posterior bronchus arose independently of each other, creating a lobe with virtually four major bronchi.

He also reported that sub-segmental bronchi of both the posterior and apical segments arising by a common stem as the fourth branch, and a common origin of anterior and posterior segmental bronchi, with the anterior bronchus bearing an accessory bronchus helping to supply the apex.

APPLETON, A. B., [1945][07], the illustration in his paper contains eleven sets of names that have been applied to the segments of the right upper lobe.

CLAGETT, O.T., AND DETERLING, R.A., Jr. [1946][32] reported that in 202 proved cases of bronchiectasis, the right lower lobe was involved in 19 %, the left lower lobe in 35 % and both lower lobes in 10 %, the lingular lobe was involved in almost 75 % of the cases in which the left lower lobe was affected, and lingulectomy thus may allow removal of all diseased portions of the left lung without sacrificing the entire upper lobe. Also, abscess, cystic disease, and tuberculosis are frequently segmental; the superior segment of the lower lobe is a relatively frequent locus of abscess.

BROCK, R.C. [1946][27] equivalented the apical, anterior and posterior segments of the right upper lobe to apical, pectoral and sub-apical segments respectively.

BOYDEN, E.A., AND HARTMANN, J.F [1946][26] have shown the variations in the upper division of the upper lobe of the left lung as: i) a simple bifurcation of the superior division bronchus into apical – posterior and anterior segmental bronchi [about 74 %], ii) splitting of the anterior bronchus [one of these portions often being the accessory anterior bronchus, in 33 %], and in 27 % resulting in a trifurcation.

ETTER, L. E. [1947][42] after an elaborate study of 50,000 consecutive roentgenograms of the thorax, states that the striking abnormality in lobation is

the presence of an azygos lobe [lobe of Weisberg], found to have an incidence of 0.26 %.

BAARSMA, P. R., DIRKEN, M. N. J., AND HUIZINGA, [1948][16] say that in the case of pulmonary tissue deprived of its bronchus, there apparently is also a collateral circulation of air, referred to as "collateral respiration" which may prevent atelectasis of that tissue. It is said to be due stomata between alveoli which allow movement of air between adjacent lobules within a lobe.

BOYDEN E.A. AND SCANNELL J.G. [1948][21] revealed that the right upper lobe bronchus gives rise to three segmental bronchi, and in about 45 % of cases these arise by trifurcation [Fig.No.8] of the lobar bronchus; in the remaining 54 % the manner was found to be a bifurcation.

SMITH, FRAUD AND BOYDEN, E. A., [1949][82] in their study of the right lower lobe, they found that inter segmental plane to lie approximately horizontal in 62 % and obliquely in the remaining 38 %. The superior segment is typically by far the largest of the five segments of the lower lobe, constituting, the upper half of this lobe in 78 %, the upper third in 14% and the upper two – thirds in 8 %.

They also found that the anterior basal bronchus is apparently constant, and arises a little below the medial one; in absence of the lateral basal bronchus or one of its sub branches [4 of 50 specimens] the anterior basal branches aerates territory normally supplied through the lateral basal branches. The common stem for the lateral and posterior basal bronchi is typically short, and

its two branches lie deep within the lobe. The posterior basal bronchus typically supplies not only the posterior basal segment but also, by virtue of its sub–superior branch, at least a portion of the sub–superior segment [84 % of 100 specimens].

BERG, R. M., BOYDEN, E.A., AND SMITH F.R., [1949][17], they say that a sub-superior or sub apical segment occurs in left lower lobe. In addition to a sub-superior bronchus proper, arising posteriorly from the inferior lobar bronchus, they found that an accessory sub superior arising as a single branch of the posterior basal in 71 % and as two branches in 13 % and an accessory sub superior from the lateral basal in 67 %.

In regard to the basal segments, they described the basal bronchi as usually [87 %] arising through a bifurcation of the basal trunk. In these cases, the medial basal bronchus arose with the anterior basal or one of its branches; however, the medial basal in 10 % arose separately from the basal trunk, as it does on the right side, and in 3 % it arose as an accessory branch from the lateral basal or branches of the lateral and posterior basal.

In contrast to the medial basal segment, they found that the anterior basal segment is the least constant of the four basal segments, and that its branches frequently varies both in origin and in the extent of its branching. In 17 % of their cases, this segment failed to reach the diaphragmatic surface; in 70 % its branches arose with the medial basal, in 13 % it arose alone in the usual location and in 17 % one of its branches was represented by an accessory one from another bronchus; while they regarded resection as being feasible

anatomically, they warned that numerous variations would have to be expected in regard to this segment.

The lateral basal bronchus is described as arising from the stem bronchus only a short distance below the combined origin of the antero medial bronchi, and in 80 % at the level of origin also of the posterior basal bronchus. In 67 % of cases this bronchus was found to give off an accessory sub–superior bronchus, in contrast to the right, where an accessory sub–superior bronchus of this origin rarely occurs. In 10 % the lateral basal bronchus was absent as such, being represented by accessory branches of the adjacent bronchi–the same was true on the right side in 8 %. In 7 % the accessory bronchi supplying the lateral basal segment arose from the posterior basal or by a multiple origin.

The posterior basal bronchus is described as the largest of those of the lower lobe, coursing downward, backward and medially; it usually gives rise to one or two accessory sub–superior bronchi, and in about 30 % one or two para–vertebral branches arise from it. The basal segments can be resected together, as in the right lung, but as already mentioned, the obliquity of the plane between these and the superior segment makes such a separation more difficulty than on the right.

BOYDEN E. A., [1949 a][22] found a transverse fissure in the left upper lobe in 8 to 100 adult specimens, separating a ‘middle lobe’ of the lung. He also says that usually this fissure corresponds to the inter segmental plane between the lingula and the remainder of the upper lobe; and does not represent a true separation of the lingular lobe, since the portion demarcated by it may contain anterior segmental bronchi.

He also furnishes that the branching of the upper division branches in the left lung is complicated by one rare and three common variations; since more than one of these variations may occur at the same time, he says that separation of individual upper division segments was not advised.

The rare variation found in 4 of 100 specimens in due to the ectopic position of the left pulmonary artery between the apico posterior and the remaining segmental bronchi. This diminishes the size of the upper and increases the size of the lower divisions.

The more common variations are tendency for the anterior bronchus to split into two stems [33 %] with downward displacement of one of these stems resulting in a trifurcation of the superior division [27 of 100 specimens] [Fig.No.9] and the tendency for branches of the apical and posterior bronchi to arise anomalously [through displacement] from other bronchi. Displacement of an important apical branch in 38 % and displacement of a posterior branch in 40 %.

He also stated that, in 73 % of specimens the inferior division simply bifurcated into superior and inferior lingular bronchi, in the remaining 27 % a posterior branch arose from the lingular stem before its division. In more than half of the cases in which this occurred [15 % of the total specimens] this posterior branch represented an upwardly displaced branch of the superior lingular bronchus, but in the remainder of the cases in which this occurred [12 % of the total specimens], this posterior branch crossed the inter segmental plane to supply the back of the anterior segment, thus offering a hazard to lingulectomy.

MORTON, DR., LASSEN K., BAXTER, E.H. [1950][74] have reported that the agenesis of the right upper and middle lobe bronchi in each of the two patients.

BOYDEN, E.A., AND HAMRE, C.J., [1951][25] have listed that i) the right middle lobe bronchus, averaging about 18 m.m. long usually bifurcates in 62 % of cases to a lateral [B^4] and medial [B^5] each supplying approximately equal segments. ii) On the other hand, in 18 % of specimens, although bifurcation occurred, the lateral and medial branches were quite unequally distributed and in another 18 % the bifurcation was such as to form superior and inferior segments to the lobe, rather than the usual medial and lateral ones, but iii) in 2 to 3 % cases trifurcation occurs, in which the two sub–segmental branches of either of the segmental bronchi arising separately. Even where bifurcation occurs, the distribution of the bronchi is not always that which would the segments are named.

As a rule, the middle lobe as a whole, rather than one of its two segments, is removed in resection of this lobe.

FERRY. R.M. Jr AND BOYDEN, E.A., [1951][44], in 100 cases investigated by them, found the superior segment of right lower lobe to be supplied exclusively by a sub – superior bronchus proper in 16 % and in 39 % exclusively by one or more accessory sub - superior bronchi from the posterior basal bronchus; and in 45 % of cases it was supplied by bronchi from both levels.

They recognized that in 24 %, the two rami of the medial basal segment enclosed the main basal vein–was not considered to be resectable. In 20 % of 50 specimens, the bronchus was absent as such, its anterior branch arising from the anterior basal and its posterior branch from a sub –superior or posterior basal stem.

BRADLEY .M. PATTEN, [1953][58], Professor of Anatomy in the University Of Michigan Medical School, enlights on a medically more significant condition which is a malformation of the terminal parts of bronchial trees known as bronchiectasis. In situs inversus of the viscera, it will be the right lung that exhibits only two lobes while the left lung that is three lobed.

STOREY C.F., AND MARRONOONI, A.G., [1954][84] have reported the absence of a left lower lobe bronchus in a young adult man.

BLOOMER, W.E., LIEBOW, A.A., AND HALES, M.R., [1960][19] found trifurcation in 52 % and bifurcation in 48 % in the superior lobar bronchus of the right upper lobe.

FRANK D ALLAN M.S., [1960][40], in his essentials of human embryology quotes that the variations in lobation are common and result in coincident variation of bronchi.

BOYDEN E.A., [1961][23] in his numerical system, refers the apical, anterior and posterior segments of the right upper lobe to B1, B2, and B3. The remaining segments were also numbered as in Table No.1.

G. J. ROMANES [1964][35] places the definition for broncho – pulmonary segments as that 'the area of lung supplied by the tertiary bronchi constitutes the broncho – pulmonary segment'.

In noting the variations in the anatomy of the lungs, he says that there occurs the fusion of adjacent lobes or accessory fissures, and azygos lobe which is rare and majority occurs on the right side. He states the partial fissure between the superior and basal broncho pulmonary segments of the lower lobe; a transverse fissure in the left lung marking off a middle lobe, and corresponding to the inter - segmental plane between the lingula and the upper lobe are other anomalies of the respiratory system.

Regarding histology, he says that mucous membrane is pseudo – stratified columnar ciliated epithelium resting on a basement membrane with goblet cells and in the lamina propria, large number of elastic fibers and glands, muscular layer and irregular plates of cartilage forming complete rings, while the smaller bronchioles have no cartilage.

G. J. ROMANES [1966][34], as a definition states that "segmental bronchi supply sectors of the lungs known as broncho pulmonary segments".

He quotes the difference between the right and the left segments as that the upper main branch of the left superior lobar bronchus supplies two segments [apico–posterior and anterior] which correspond to the three segments of the right superior lobar bronchus [apical, posterior and anterior]. The lower main branch of the left superior lobar bronchus supplies superior

lingular and inferior lingular corresponding to the lateral and medial segments of the middle lobe bronchi of the right lung.

ATWELL [1967][13], at the Oserholt Thoracic Clinic, described the absence of four lobar bronchi, one of the right upper lobes and three of the left upper lobe in a series of 1,200 consecutive, complete, and bilateral bronchograms–an overall incidence of 0.16 %.

MANGIULEA, V.C., STINGHA R.V., [1968][70] said that an accessory cardiac bronchus is a super numerary bronchus arising from the medial aspect of the right main bronchus or intermediate stem bronchus proximal to the origin of the right superior [apical basal] segmental airway of the lower lobe. It is either blind–ending, in which case it may have a nodule of unaerated lung tissue at its tip or supplies a small ventilated “lobule”.

HOLLIN SHEAD, [1971][05] described that the so-called inter – segmental “planes” are, of course, sometimes crossed by small bronchi and arteries, where the various segments interlock with each other, and occasionally by larger bronchi and vessels which arise anomalously from one segment and supply an appreciable part of another segment. The effects of interference with the major anomalous bronchi and arteries are probably not fully known, and appear not yet to have been discussed in any detail by surgeons, but certainly minor bronchi and vessels are routinely interrupted in segmental resection with no apparent adverse effects.

He defines the broncho - pulmonary segments as anatomical units of major lung segments with their own bronchial, arterial and venous supply, so

do the bronchi within a lobe, branch and rebranch to supply smaller and smaller segments of tissue, anyone of which might be regarded as a broncho–pulmonary segment.

The now standard terminology of the broncho – pulmonary segments and the segmental bronchi is based largely on the Jackson and Huber, [Table No.2] slight variation from that are as follows : in both lungs the frequency used clinical terms " apical " and " cardiac basal " are accepted as synonyms for " superior " [of the inferior lobe] and " medial basal " ; and the left inferior lobe is now described as having an anterior and a medial basal segment instead of an antero medial one .

LANDING B.H., LAWRENCE T.Y., PAYNE V.C.Jr., ET AL [1971][66] stated that the lateral inversion of right and left sided airways occurs in situs inversus.

HAMILTON, BOYD AND MOSSMAN [1972][59] explain their view that occasional monopodial branching of the stem bronchi account for the accessory bronchi and lobes often found in the adult lungs.

GRAY S,W., SKANDALAKIS, J.L., [1972][54] mention that the pattern and completeness of the pulmonary fissures is variable. Variations may be i) without alteration of the underlying bronchial pattern [supernumerary fissures or lobes]; ii) superficial septation produced by an extrinsic blood vessel [azygos lobe]; and iii) variations of the bronchial pattern with or without external evidence [left eparterial bronchus or tracheal lobes].

MARIANO S.B.DI FIORE [1973][75] quotes the histology of the bronchial tree as follows:

TRACHEA:

Its supporting tissue is hyaline cartilage. Tracheal tube is lined by mucosa, in lamina propria present are the serous and mucous acini ducts opening into the lumen of the trachea. Surface epithelium is pseudo stratified columnar ciliated with goblet cells. Chondrocytes near the surface of the cartilage are flattened and gradually become similar to the fibrocytes of the perichondrium.

PRIMARY BRONCHI:

First as that of the trachea, when they enter the lung, the C–shaped cartilage is replaced by separate plates of cartilage which encircle the bronchus and the smooth muscle spreads out from the trachealis muscle to form an incomplete layer around the lumen.

SECONDARY OR LOBAR BRONCHUS:

Is identified by closeness of its several cartilage plates. The lining of the bronchus is a pseudo stratified columnar epithelium. Making up the wall, one sees in succession - a thin lamina propria, a narrow layer of smooth muscle, a sub mucosa in which bronchial glands are scattered, hyaline cartilage plates and an adventia.

SEGMENTAL BRONCHI:

Have the similar structure but the epithelium becomes lower and the other elements increase in amount.

LANDING B.H., AND WELLS T.R., [1973][67] presented an interesting case in which a 2 month old infant had hypoplasia of the right lung as well as the absence of the middle lobar bronchus.

They also reported a second infant with a similar syndrome associated with an absence of the right upper lobe bronchus. Both these infants had other multiple congenital defects and the lobar bronchial agenesis was confirmed at the time of autopsy.

D. J. DU PLESSIS [1975][08] expresses that each lung consists of ten segments, [Fig.No.10] each broncho pulmonary segment is a unit in the architecture of the lungs which, though they appear to be in continuity, are yet separate entities and thus the individual segments can be excised with little loss of blood or leak of air, if inter segmental planes can be adhered to.

He also enlights that each lung is divided into lobes by the oblique fissures or horizontal fissure also, the knowledge of which is essential in locating and operating on lung abscess.

He also states that the right middle bronchus lies in the lymphatic pathway from the right lower lobe , it is closely surrounded by glands draining the lower lobe and middle lobes which are particularly vulnerable to the effects of glandular enlargement that may result in

bronchiectasis; near the acute angles formed by branching - there usually lies a lymphatic gland.

He also points out that the posterior segment of the right upper lobe is by far the most important part of this lobe and perhaps of the both lungs. It is often the primary site of tuberculosis, septic pneuminitis, or abscess.

He also explains that the lower lobe, largest of the three, is made up of a superior and an inferior portion.

In the inferior portion , there are four segments namely anterior basal, medial basal, lateral basal and posterior basal segments among which, the posterior basal segment contributes to the mediastinal surface of the lobe, the lateral basal segment is also partly posterior, the anterior basal segment is lateral also the medial segment [cardiac] is entirely medial and diaphragmatic.

He mentions three varieties of super – numerary lobes of the lung. One is the lobe of azygos vein [Fig.No.11 and 11a] due to abnormality of azygos vein . The other two are upper azygos lobe and lower azygos lobe which are not associated with azygos vein [Fig.No.12] but are accessory lobules of lung tissue and named according to their situations above or below the hilum.

He describes super – numerary bronchus found in 50 % of cases which is called the sub – superior bronchus.

He points out that lingual is liable to be involved with the left lower lobe bronchiectasis.

In regard to the broncho pulmonary segments, he says that the arrangements on the two sides would be essentially the same but for the fact that the lingular bronchus on the left usually comes from the upper lobe bronchus and on both sides. The superior segment of the lower lobe is often anatomically fused with the upper lobe, especially behind.

GONZALEZ - CRUSSI F, ET AL [1976][49] reported the rare anomaly, a so – called bridging bronchus that arises from the left main stem bronchus and crosses the mediastinum to supply the right lower lobe and, at times, a portion of the middle lobe.

BAILEY AND LOVE [1977][15] say that there are ten segments in right lung and nine segments in the left lung where the medial basal segment is absent and enlights on the developmental anomalies such as failure of a main bronchus to develop results in unilateral agenesis whilst failure of a lobar bronchus to develop, produces lobar agenesis. Failure of the developing bronchial bud to link up with the pulmonary artery system occurs occasionally. In this case, ectopic bronchial buds develop anomalously, producing a mass of bronchial elements which often lose their connection with the parent bronchi. Vascular supply is derived direct from the descending aorta. In adult life the condition presents as a bizarre cystic mass, usually lying in the posterior aspect of the lower lobe with large systemic arteries the size of the radial artery or even large entering the mass through the pulmonary ligament – intralobar sequestration.

DAVIDSON [1977][37] writes that the right lung differs from the left in having three lobes instead of two, divided by an extra horizontal fissure, each lobe is composed of two or more broncho–pulmonary segments which represent the portions of lung tissue supplied by the main branches of each lobar bronchus. He firmly points out that there is no medial basal bronchus on the left side and hence only nine segments on the left side.

DANDY W.F.,Jr [1978][36] stated that the frequency of incomplete fissures in different series ranges from 12.5 % to 73 % for the major fissures and from 60 % to 90 % for the minor fissures. These defects are important because they allow collected air drift between lobes, permit disease to “cross” fissures and also limit the accumulation of pleural fluid in the interlobar portions of the pleural cavity.

PROTO AV, SPECKMAN JM [1979][77] stated that the superior accessory fissure separates the superior[apical basal] segment of a lower lobe from the basal segments and superficially resembles a minor fissure on a frontal radiograph. It was identified on 6 % of lateral radiographs.

JOHN V. BASMAJIAN [1980][51] reveals that each segmental bronchus, together with the portion of the lobe it supplies is called a broncho pulmonary segment. He also states that there are ten segmental bronchi on the right side usually and eight on the left. He noted the variation of the lobe of the azygos vein results when the apex of a developing right lung encounters the arch of the azygos vein and is cleft by it. The vein is suspended in a pleural “mesentery”, and it may cause a shadow by radiographs.

He says that microscopically the bronchi have plates of cartilage scattered irregularly round a circular lumen.

STARSHAK RJ, STY JR, WOODS G, et al [1981][83] isolated, - cases of the so called “bridging bronchus”, where the right lower lobe bronchus arises from the left main bronchus and crosses or “bridges” the mediastinum to reach the right lung, and said that this anomaly is exceedingly rare.

STARSHAK R.J, [1981][83] AND BERTUCCI G.M. et al [1987][18] reported a patient with the anomalies of bridging bronchus and they say that this condition may be frequently associated with either a pulmonary venous or a pulmonary artery abnormality.

T. W. SADLER [1983][69] says that more frequently seen is the abnormal divisions of bronchial tree resulting in supernumerary lobules. These variations of the bronchial tree are of little functional significance, but may cause unexpected difficulties in bronchoscopy.

More interesting are ectopic lung lobes which arise from the trachea or esophagus. It is believed that these lobes are formed from additional respiratory buds of the foregut which develop independently of the main respiratory system.

Most important clinically are congenital cyst of the lung which are formed by dilation of the terminal or larger bronchi. These cysts may be multiple, giving the lung a honeycomb appearance on radiographs, or they may be restricted to one or more larger ones. Since cystic structures of the lung usually drain poorly, they frequently cause chronic infections.

GODWIN J.D., TARVER R.D., [1985][48] explain the inferior accessory fissure usually incompletely separates the medial basal segment from the rest of the lower lobe. Because this segment lies antero medially in the lower lobe, the accessory fissure has components that are oriented both sagitally and coronally and are tangential to frontal and lateral radiographic beams; even so the fissure is rarely seen on lateral radiographs. The frequency of occurrence is difficult to ascertain because the fissure varies greatly in depth and prominence from one examination to the next.

AUSTIN J.H., [1986][14] described that the left minor fissure is present in 8 – 18 % of people but is only rarely detected on postero anterior and lateral radiographs, with a reported frequency of 1.6 %. It separates the lingula from the rest of the left upper lobe and is analogous to the minor fissure. It is usually arched and located more cephalad than the minor fissure. It slopes medially and downward.

WOODRING, J.H. HOWARD, R.S., AND REHM, S.R. [1991][92] describe the tracheobronchomegaly as a rare disorder of the lower respiratory tract characterized by marked dilatation of the trachea and bronchi, due to a congenital tissue defect resulting in a primary atrophy of the elastic and smooth muscle of the trachea and major bronchi. It occurs rarely in siblings and is associated with Ehlers – Daulos syndrome and cutis laxa. Plain chest films will demonstrate the ectasia of the trachea and the main stem bronchi. Bronchography will confirm the diagnosis if necessary and differentiate this lesion from acquired bronchiectasis.

MORI M, KIDOGAWA H, MORITAKA T, ET AL [1993][73] describe bronchial atresia as, a lobar or segmental bronchus ends blindly in the lung tissue. Lung tissue distal to the bronchial atresia expands and becomes emphysematous as a result of air entering through the pores of kohn. Beyond the atretic segment, but proximal to the hyper inflated lung the terminal airway is mucous filled. It is believed that the bronchial bud some how separates distally from the proximal bronchial bud and continues to develop. Another potential explanation is that there is a vascular insult of the airway in the atretic segment. In either case, the distal airway continues to develop normally.

The most common location is in the left upper lobe; then the left lower lobe, followed by the right upper lobe.

ALFRED P. FISHMAN, [1998][45] defines that the units of lung parenchyma are broncho arterial units, which share their venous drainage with neighboring units, having important functional and practical consequences. Expect for the lobes, none of the units are separated from each other by complete connective tissue septa.

MARVIN I, SCHWARZ AND TALMADGE E.KING Jr. [1998][64] quoted the correlation of pathology of interstitial lung disease with radiological studies stating the presence of honey combing in idiopathic pulmonary fibrosis and nodular thickening along the septa seen in High Resolution Computerized tomography.

RICHARD G. KESSEL [1998][72] gives an account of the microscopic structure of the intrapulmonary bronchi as that they are lined by pseudo

stratified ciliated columnar epithelium with goblet cells. Seromucous glands are present in the sub mucosa. Solitary lymphatic nodules are present in the lamina propria of bronchi and appear a few days after birth.

In addition, ß – lymphocytes of both the I_GA and I_GE classes are located in the lamina propria of the bronchi. Further, I_GA secreting plasma cells can be observed in the lamina propria and in close proximity to glands, which constitute the bronchus associated lymphatic tissue.

ANTON SEBASTIAN [1999][01], has explained the following words in the dictionary of the history of medicine

Alveolus:[Latin: alveus, hallow]

Bronchus: [Greek : bronchus, windpipe]. Derives its name from the brief by the Greek philosopher Plato [428 – 348 BC] that the fluids when drunk, passed down the trachea, creating its moistness [Greek : brechein = to moisten].

Bronchogram: [Greek : bronchus, windpipe + graphein, to write].

Bronchoscopy:[Greek : bronchus, windpipe + scopos, a watcher].

CHUMMY S. SINNATHAMBY [1999][68] presents that there are typically ten broncho pulmonary segments in each lung in which some segmental bronchi may share a common stem i.e., apico posterior in left upper lobe and in the lower lobe, the medial and anterior basal segments and the lateral and posterior basal segments arise from common stem bronchi subsequently subdivide.

According to him, each lung develops from a bud at the lower end of the laryngotracheal tube that grows down from the floor of the primitive pharynx. These endodermal buds from the epithelial part of the lung; the connective tissue, cartilage and muscle of the bronchial tree from the surrounding mesoderm. By the seventh month, there are sufficient alveoli to sustain a viable infant.

B.YOUNG AND J.W.HEATH [2000][91], in Wheater's functional histology listed out that, the respiratory epithelium is pseudo-stratified columnar upto the segmental bronchi. Numerous goblet cells in upper bronchi, scattered throughout the bronchial tree are the Kulchitsky cells in the lower respiratory tract.

The lamina propria consists of lymphoid aggregates; a smooth muscle lies deep to the mucosa, sub mucosal layer contains serous and mucous glands which become less numerous progressively and absent beyond the tertiary bronchi.

Cartilage which lies outside the sub-mucosa diminishes as caliber of airway decreases and absent completely beyond the tertiary bronchi.

ASIM KUMAR DUTTA [2000][41] essentially brings out that in renal agenesis bronchial branching is reduced resulting in pulmonary hypoplasia which suggests direct renal factor which is essential for lung development.

JOHN F.MURRAY AND JAY A. NADEL [2000][87] pictures out microscopically the bronchus contains bronchial mucosa consisting of pseudo stratified ciliated columnar epithelium and goblet cells, electron

microscopically the basal bodies, which produce a dark band immediately beneath the cilia.

INDERBIR SINGH [2001][60], in human embryology, lists out the anomalies of lung and bronchi as follows:

One lung or one of its lobes and associated bronchi may fail to develop or may remain under developed; Absence of horizontal fissures results in only two lobes in the right lung; Presence of a transverse fissure result in three lobes in left lung. In a condition it may occur that medial basal segment and superior segment of the lower lobe may be separated from others by a fissure.

He also presents about the azygos lobe which lies medial to the azygos vein, accessory lobes [upper and lower] and the sequestration by the lung tissue, the condition most frequently seen in the lower lobe of the left lung.

INDERBIR SINGH [2002][86], in his text-book of human histology says that the cartilages in the walls of the bronchi become irregular in shape, the amount of muscle and sub-epithelial lymphoid tissue in the bronchial wall increase as the bronchi become smaller. The larger bronchi are lined by pseudo- stratified ciliated columnar epithelium and as the bronchi become smaller the epithelium is at first simple ciliated columnar – then non-ciliated columnar.

WARREN M.GOLD [2002]10, in his Atlas of procedures in Respiratory Medicine defines that each segmental bronchus and its

accompanying pulmonary artery supply a region of a lobe known as a broncho-pulmonary segment.

In histological aspects he says that the bronchi are lined by pseudo-stratified columnar epithelium containing ciliated, goblet, and basal cells. Beneath the epithelium, longitudinal elastic fibres run through the lamina propria, and a layer of smooth muscle circumferentially surrounds the airways. Sub mucosal glands are located between the smooth muscle and the outermost layer of cartilage.

In bronchiole, simple columnar epithelium consists of ciliated cells and Clara cells. The secretory Clara cells replace goblet cells in the bronchioles. The bronchiolar wall lacks cartilage and is supported by elastic fibres and smooth muscle.

WILLIAM J. LARSEN: [2002][04] denotes that the tertiary bronchi distributed to independent functional units of the lungs are called the bronchopulmonary segments. There are 10 bronchopulmonary segments in each lung even though the right lung has 3 lobes and the left two.

He also, quotes that when the normal branching pattern is disrupted less severely it results in reducing the number of pulmonary segments resulting in pulmonary hypoplasia.

TSUNEZUKA AND COLLEAGUES [2002][90] reported the absence of right upper lobe bronchus in an elderly woman.

T.S. RANGANATHAN [2003][12] defines the tertiary bronchus as segmental bronchus and the accompanying division of the pulmonary artery supply a definite part of the lung and the entire unit which is functionally independent is referred to as the broncho pulmonary segment.

He explains the broncho pulmonary segments to be present as ten in the right lung and eight in the left lung – left having the apico-posterior and anterior in upper lobe and absence of medial basal segment in its lower lobe.

He ensures that a knowledge of the broncho pulmonary segments is necessary for interpretation of the bronchogram, doing bronchoscopy and deciding suitable position for drainage in lung infection.

FRANK W.SELL KE, [2005][78] quotes that bronchiectasis is an abnormal dilation of the bronchi or bronchioles. It is believed to be secondary to failure of the mesenchyme to differentiate into cartilage and muscle. It results in a chronic, mildly productive cough with recurrent pneumonia.

PETER ARMSTRONG - [2005][63] in denoting the variations in bronchial anatomy, quote that there may be a common origin of the right upper and middle lobe bronchi.

THOMAS W. SHIELDS [2005][46] implements that “the essential anatomic unit of the lung, the broncho pulmonary segment, was that portion of the lung substance that represents the total branching of a major, segmental subdivision of a lobar bronchus. These units are named for their topographic position in the lung [Fig.No.13,13a and 13b].

On quoting the variations in the left lung he says that the common variations are in the distribution of the segmental bronchi from the superior and

inferior divisions of the left upper lobe bronchus and the presence of a sub superior or accessory sub superior bronchus arising from the lower lobe bronchus. Many of these deviations from normal have little clinical importance but are significant at the time of surgical resection of various portions of the lungs.

In **GRAY'S ANATOMY [2005][53],** the definition of the broncho pulmonary segments is given as "primary branches of the right and left lobar bronchi are termed segmental bronchi because each ramifies in a structurally separate, functionally independent unit of lung tissue".

There in it was given that the right lung has got superior, middle and inferior lobes with horizontal and oblique fissures in which the superior lobe has apical, posterior and anterior segments, middle lobe the lateral and medial segments and the inferior lobe superior [apical], medial basal, anterior basal, lateral basal and posterior basal segments.

The left lung has got superior and inferior lobes with an oblique fissures only in which the superior lobe has apical, posterior, anterior, superior lingular and inferior lingular and the inferior lobe has superior [apical], medial basal, anterior basal, lateral basal and posterior basal segments.

He also quotes that a common origin of right upper lobe and right middle lobe or an accessory cardiac bronchus and a right lobe bronchus that may arise from the main stem bronchus are the variants which are largely asymptomatic but occasionally may cause haemoptysis, recurrent infection and development of bronchiectasis of the airway.

In more than half of all right lungs a sub superior[sub apical] segmental bronchus arise posteriorly from the right inferior lobar bronchus 1-3 cms below

the superior segmental bronchus, and is distributed to the region of lung between the superior and posterior basal segments.

He also states that the medial part of the upper lobe is partially separated containing the terminal part of the azygos vein forming the '**lobe of the azygos vein'** supplied by one or more branches of the apical bronchus.

Less common variations are the presence of an inferior accessory fissure, which separates the medial basal segment from the remainder of the lower lobe and a superior accessory fissure which separates the apical segment of the lower lobe, from the basal segments. A horizontal fissure is a normal variant found in about 10% of patients.

The statement is also there when a portion of lung exists without the appropriate broncho vascular connections; it is usually supplied by the systemic vasculature. Pulmonary sequestration segments may be extra lobar usually found below the left lower lobe which usually embedded in normal lung, classically the posterior basal segment of the left lower lobe.

It is also found that the identification of the completeness of the fissures is important prior to lobectomy, because individuals with incomplete fissures are more prone to develop post-operative air leaks.

As the features of the lining epithelium of the bronchial tree, Gray says that,

The primary, secondary, tertiary bronchi are lined with ciliated columnar epithelium, U-shaped cartilage in primary bronchus and irregularly shaped and

helical plates in secondary and segmental bronchi with trachealis muscle in the primary bronchus and helical bands in secondary and tertiary bronchi.

Electron microscopic studies show along with ciliated columnar cells- the goblet cells, Clara cells, basal cells, brush cells, neuro - endocrine cells, lymphocytes and mast cells.

KEITH L.MOORE AND T.V.N. PERSAUD [2005][88] their view about the congenital lung cysts were that, the cysts [filled with fluid or air] were thought to be formed by the dilation of terminal bronchi. They probably result from a disturbance in bronchial development during late fetal life. If several cysts are present, the lungs have a honey comb appearance on radiographs. These are usually located at the periphery of the lung.

They also state that the lung hypoplasia is characterized by a markedly reduced lung volume.

KEITH L.MOORE [2006][33] in his text-book, states that the broncho-pulmonary segments are pyramidal shaped, largest sub divisions of a lobe, separated from adjacent segments by connective tissue septa, supplied independently by a segmental bronchus and a tertiary branch of the pulmonary artery, named according to the segmental bronchi supplying them, drained by inter segmental parts of the pulmonary veins that lie in the connective tissue between and drain adjacent segments, surgically resectable and usually 18-20 in number [10 in right lung; 8-10 in the left lung] depending on the combining of segments.

He also quotes that the more common ‘accessory’ lobe is the ‘azygos lobe’.

MATERIALS AND METHODS

I) MATERIALS for the :

i) Storage of the collected lung specimens

ii) Dissection [Fig No.14]

iii) Bronchogram procedures [Fig No.14]

Dye Contrast Bronchogram

iv) Luminal casting [Fig No.14]

v) Histology [Fig No.14]

vi) Comparative anatomy [Fig No.14] and

vii) Clinical study

i) STORAGE :

1) Human lung specimens

2) Container to store [Fig No.15]

3) 10 % formalin as the preservative

ii) DISSECTION :

1) Scalpel

2) Curved artery

3) Tissue forceps

4) Scissors

iii) BRONCHOGAM :

DYE CONTRAST

1) Six pairs of adult human lungs and three pairs of fetal lungs.

2) A pair of gloves.

3) Inj. Trazograf 76 % - five ampoules.

4) Normal saline --- To wash the airway

--- To dilute the contrast

5) One 20 ml syringe to rinse the luminal infrastructure of the bronchial tree of the lung.

6) One 10 ml syringe –to inject the dye.

iv) LUMINAL CASTING:

1) Paired human lungs.

2) Silicon gel – transparent.

3) Caulking gun to instill the silicon gel by shooting with force.

4) Thread to tie.

v) HISTOLOGY:

1) For time processing, embedding, section cutting, mounting and staining the histology lab was used.

2) Haematoxylin and eosin stains.

3) Fresh slides and cover – slips

4) Alcohol of 20 % , 50 % , 70 % , 90 % and absolute.

5) Xylol.

6) Canada balsam

7) Glass marking pencil

vi) **COMPARATIVE ANATOMY**:

1) Two pairs of goat lungs collected from the slaughter house

2) Silicon gel , both black and white

vii) CLINICAL STUDY:

1) Ten clinical cases with various lung diseases / disorders

2) Bronchoscopy.

II) METHODS

i) COLLECTION & STORAGE OF THE SPECIMENS:

Twenty pairs of human lungs were collected from the cadavers allotted to the I M.B.,B.S., students at the Upgraded Institute of Anatomy, Madras Medical College, Chennai - 3. Eight pairs of fresh human lungs were collected between the age of 7 years and 70 years for the study from the Institute of Forensic Medicine during the procedure of the post mortem , within a period of three months. Four fetuses collected and stored already in our Institute, were taken for the fetal cadaveric study.

The morphology of the 64 specimens collected were studied and then stored in 10 % formalin solution, prepared by adding one part of

formaldehyde with nine parts of water. All the procedures were performed taking these specimens

ii) **METHOD OF DISSECTION:**

On the dissection table , by using the suitable instruments such as tissue forceps, curved artery forceps and scissors , each lung was dissected.

Starting from hilum , each lung was proceeded to its periphery to expose the branching pattern of the bronchial tree which was observed and recorded . The photographs were taken in necessary fields.

iii) **BRONCHOGRAM:**

a) CONTRAST BRONCHOGRAM USING THE DYE:

1) IN ADULT LUNGS:

Six pairs of the lung with the trachea in situ were taken and washed well with tap water to remove all the blood clots . The lumen of the airway is cleaned by injecting 20-40 ml of normal saline solution, till the syringed out saline is clear. The lungs were held upside down for minimum of half–an-hour to allow the airway to dry– up. Inj. Trazograf 76 % of each ampoule [20 ml] was diluted with equal parts of the normal saline and was injected into each of the [Lungs] bronchial tree through the trachea using 10 ml syringe and the tracheal opening was sealed with cotton plug. Then with proper markings for the side identification, radiographic pictures of the specimens were taken in the Barnard institute of Radiology, Government General Hospital , Chennai – 03.

2) IN FETAL LUNGS:

The airways of the four fetal lungs were cleaned with normal saline injected through the crico - thyroid membrane . 0.2–0.5 ml of the dye prepared for the adult lung procedure was injected into the bronchial tree and sealed with plugs, for taking their radiographs.

iv) LUMINAL CASTING:

A pair of eight lung specimens were rinsed at first with normal saline and then with tap water to clear the airway. By keeping them in air inverted position, the water particles were drained. The transparent silicone gel of 60-80 ml in normal adult lung and 30–60 ml in lungs with pulmonary hypoplasia was injected into the tracheo bronchial tree using the "caulking gun". The upper ends of the trachea were tied with thread and kept for twenty-four hours for the silicon gel to settle. The specimens were boiled to half an hour to one hour in aluminium vessel. Then the macerated lung tissues were removed. Now the clean silicon casts were ready for the study.

v) HISTOLOGY: PREPARATION OF THE SLIDES AT VARIOUS LEVELS:

By the conventional dissection method , a pair of the lungs was dissected and bits of specimen were taken from the levels of trachea , principal bronchus , tracheo - bronchial junction , secondary bronchus , tertiary bronchus and the lung alveoli . Bits were preserved in 10 % formalin , suitably labeled and kept aside for 24 hours.

Then the bits were dehydrated in ascending grades of alcohol viz., 50%, 70%, 90% & absolute alcohol for 12 to 24 hours in each of these grades. They then were cleared by treating with xylol for two hours. Then passed through three successive stages of the molten paraffin keeping for half an hour in each to remove the traces of xylol and to impregnate with paraffin.

Using the L mould, blocks were prepared. The paraffin blocks were trimmed and sections were cut by using rotatory microtome to the thickness of 3 - 5 microns . Sections were floated in warm water and mounted on the slides , smeared with egg albumin.

vi) STAINING:

The paraffin was removed by covering the sections with xylol . Xylol was removed using the descending grades of alcohol. Stained with hematoxylin and eosin stains for 5 and 2 minutes respectively . Washed with alcohol. Removed the alcohol with xylol. Now , the cleared sections were covered with cover-slips placing the Canada balsam over the section, a drop each, which were ready for the microscopic study.

Vii) COMPARATIVE ANATOMY:

Two pairs of goat lungs were obtained from the slaughter house and studied the pattern of the bronchial tree after doing the luminal casting as the procedure used for the human lungs.

Viii) CLINICAL STUDY:

10 cases of various clinical signs and symptoms were selected from the Institute of Thoracic Medicine and the Institute of Cardio Thoracic Surgery, Government General College, Madras Medical Hospital, Chennai–3. Bronchoscopy was performed in needed cases. Bronchial lavage, bronchial brushing and bronchial wash were done in 1, 2 and 1 cases respectively. Their histopathological reports were also obtained. In one case, ultrasound sonograph guided trans-thoracic needle biopsy was performed and histopathological examination was done.

Arriving at the diagnosis , the cases were subjected for the surgical and medical management depending on their eligibility .

BRONCHOSCOPY:

With the trans - tracheal infiltration of 2 % xylocaine and oral cavity sprayed with 20 % xylocaine , the nasal nares are lubricated and flexible bronchoscope is inserted though the trans - nasal route . The instrument is passed between the two vocal cords to enter the upper part of the trachea . On visualizing the carinal bifurcation at the end of the trachea , the bronchoscope is maneuvered to visual the right main bronchus - three segmental bronchi and sub segmental bronchi . Then the intermediate bronchus is entered with prior inspection of middle lobe bronchus and apical basal bronchus before entering into the rest of the four basal segments of the lower lobe . The procedure is followed for the left lung also to visualize its segments [Fig No.16, 16a and 16b].

BRONCHIAL LAVAGE:

Injecting aliquots of 20 ml of isotonic saline and then 10 ml of air slowly into the bronchus and then removed with slow suction . The amount usually injected is 100 ml of saline , of which 40 – 60 ml is generally retrieved.

BRONCHIAL BRUSH:

It is done more for growth which is not reachable by biopsy e.g., infiltrating growth and highly vascular growth.

On reaching the target area , with the brush end , the lesion is brushed to get the tissues from the lesion for histopathological smear .

BRONCHIAL WASH:

Here the input volume of isotonic saline is 20 - 30 ml and the aspirate / wash will be 15 - 20 ml .

U.S.G. GUIDED TRANS - THORACIC NEEDLE BIOPSY:

With the infiltration of adequate local anesthesia into the skin of the chest wall after test dose , the needle is inserted under computer tomographic ultrasound sonographic C.T.U.S.G. visualization with the patient holding the breath , lying either in supine or prone. Biopsy is done using the cutting needle and may have to be repeated if sufficient sample is not obtained.

Post trans - thoracic needle biopsy check radiograph is immediately taken to rule out complications like pneumothorax .

OBSERVATION

From all the thirty two pairs of the (right & left) lungs, the observation was performed under the parameters of :

I. APLASIA AND HYPOPLASIA OF LUNGS : - where aplasia denotes the absence of the lung and hypoplasia, decrease in the lung volume with or without the alternation in the pattern of the segmental bronchi distribution.

II. NUMBER AND COMPLETION OF THE FISSURES : To denote whether there is any accessory fissure or there is any incomplete fissure.

III. NUMBER OF LOBES IN RIGHT AND LEFT LUNGS :

IV. BRANCHING PATTERN OF THE BRONCHO - PULMONARY SEGMENTS BY THE FOLLOWING METHODS :

1. Conventional dissection method

2. Luminal casting method and

3. Radiological method

IV. Number of SEGMENTS IN EACH LUNG

VI. CLINICAL STUDY - was done to observe the types of diseases involving the extent of the segments with or without the surgical interventions.

VIII. The histological alternation of the bronchopulmonary tree pattern was studied microscopically.

I. APLASIA AND HYPOPLASIA

In all the 32 pairs of lung specimens, both right and left lungs were present and pulmonary aplasia was not found in my study.

Out of all the 32 left lung specimens two (6.3%) were found to be hypoplastic which were smaller than their corresponding right lungs [Fig No.17 and 18].

II. NUMBER AND NATURE OF FISSURES :

Right lung: In right lung both oblique and horizontal fissures are present normally. The oblique fissure [Fig No.19] cuts the inferior border of the lung about 7.5 cms behind its anterior extremity starting superficially on the medial surface at the posterio-superior part of the hilum, ascending obliquely backwards to cross the posterior border of the lung 6 cms below the apex, then descending forwards across the costal surface to reach the lower border almost at its anterior end, finally ascending on the medial surface to the lower part of the hilum.

The short horizontal fissure [Fig No.19] begins in the oblique fissure near the mid-axillary line, running horizontally fowards, cuts the anterior border on a level with the sternal end of the fourth costal cartilage; on the mediastinal surface it may be traced backwads to the hilus.

All the 32 right lungs showed [Table No.3] one oblique fissure present normally. On observing the horizontall fissure, 29 right lungs showed one complete horizontal fissure. In 3 right lungs the horizontal fissure was incomplete [Fig No. 20,21 and 22] and in these there specimens the horizontal fissure did not reach the hilum on the mediastinal surface. An accessory horizontal fissure was found in the lower lobe of one right lung dividing into upper and lower parts [Fig No.23]. In this specimen, the normal horizontal fissure dividing the upper and middle lobe is also present.

In one right lung, in its upper lobe, a horizontal fissure starts from the hilum, cuts the anterior border, runs for the distance of 5cms in the costal surface, in addition to normal horizontal fissure [Fig No.20].

IN LFET LUNG

Normally the oblique fissure [Fig No.19] begins superficially on the medial surface at the postero - superior part of the hilum. It ascends obliquely backwards to cross the posterior border of the lungs 6 ms below the apex, then descends forwards across the costal surface, to reach the lower border almost at its anterior end. It finally ascends on the medial surface to the lower part of the hilum.

In 32 left lungs, the normal oblique fissure was observed. The horizontal fissure in addition to the oblique fissure was found in two foetal left lungs [Table No.4] in this study starting from the cardiac notch running laterally to join the oblique fissure [Fig No.24 and 25].

III. NUMBER OF LOBES IN EACH LUNGS [Table No.5]

In all the 32 right lung, in 3 specimens (9.4%), presence of the azygos lobe was observed [Fig No.26, 27 and 28].

In one right lung an accessory lobe was found separated from the upper lobe by a deep cleft [Fig No.26].

In one right lung four lobes were present in which the upper lobe was separated by means of an incomplete horizontal fissure into two lobes [Fig No.27].

One right lung had four lobes in which the inferior lobe was separated into upper and lower parts by means of a horizontal fissure [Fig No.28].

In all the 32 left lungs, two had three lobes, both found in the foetal lungs in which one is a case of situs inversus and the other conjoint lower limbs. In both these cases, the right lungs were found to have the usual three lobes [Fig No.24 and 25].

In 2 speciemens, it was noted that the azygos lobe of the specimen was supplied by the apical and posterior segmental bronchi and the rest of the upper lobe of the specimen was supplied by the anterior segmental bronchus of the right superior lobar bronchus [Fig No.29].

In 1 specimen of right lung, it was noted that the part of its inferior lobe above the accessory horizontal fissure was supplied by the posterior and lateral basal segmental bronchi and the part below the accessory horizontal fissure was supplied by the apical basal, medial basal and anterior basal segmental bronchi.

IV. BRANCHING PATTERN OF THE BRONCHIAL TREE

This is studied by means of three methods

1. Conventional dissection method
2. Luminal casting method and
3. Radiological method

1. CONVENTIONAL DISSECTION METHOD

14 pairs of the adult lungs were taken under this method for the study.

Also 06 pairs of the adult lungs subjected for bronchogram procedure[Fig No.30(i) and 30(ii)] and 04 pairs of feotal lungs which were subjected for bronchogram procedure [Fig No.30(iii)] by injecting the dye were also studied by dissection method after completing the procedures.

2. LUMINAL CASTING MEHTOD

8 pairs of adult lungs were taken for the study by casting procedure. The prepared castings were observed and the findings noted.

i. Principal Bronchi

In all the 32 pairs of the lungs (28 adult and 04 foetal), the trachea was found to bifurcate into right and left primary bronchi.

ii. Secondary Bronchi

a. Right Primary Bronchus

The right primary bronchus usually gives rise to its first branch, the superior lobar bronchus, then continues as the intermediate stem bronchus

which enters the pulmonary hilum postero inferior to the pulmonary artery and divides into a middle and an inferior lobar brochi. The superior lobar bronchus runs superolaterally and enters the hilum.

The middle lobar bronchus starts about 2 cms below the superior lobar bronchus from the front of the right bronchus intermedius and descends anterorlaterally.

The inferior lobar bronchus is the continuation of the principal bronchus beyond the origin of the middle lobar bronchus.

In the present study, right main bronchus after giving rise to superior lobar bronchus reaches the hilum of right lung where it divides into middle and inferior lobar bronchi were in 23 specimens (71.9%) and in the remaining 9 specimens the middle lobar bronchus arises from the superior lobar bronchus [Fig No.31(i) 31(ii) and 31(iii)].

Among these 09 specimens, in 08 specimens (25%), the middle lobar bronchus arises from the superior lobar bronchus and the intermediate bronchus continues as the inferior lobar bronchus [Fig No.31(i) and 31(ii)] and in 01 specimen, [Fig No.31(iii)] (03.1%) the middle lobar and the inferior lobar bronchi arise in a common stem from the superior lobar bronchus in which the bronchus intermedius is rudimentary (Table No.6).

b. Left primary Bronchus

The left principal bronchus, enters the hilum of the left lung and divides into a superior and an inferior lobar bronchus normally which was observed in

31 left lungs and in one specimen the principal bronchus does not divide into secondary bronchi.

In the present study of 32 left lungs, in 29 (90.6%) the left superior lobar bronchus arises from the anterior lateral aspect of its parent stem, curves laterally and soon divides into two bronchi and one is distributed to the left upper lobe and the other to the lingula. The left inferior lobar bronchus descends posterolaterally and divides to supply the lower lobe.

In one specimen [Fig No.32] (3.1%), the left principal bronchus does not divide into secondary bronchi and there is agenesis of both the upper and lower lobar bronchi.

In two specimens [Fig No.33 and 34](.6.3%), the lingular bronchus arises from the inferior lobar bronchus.

iii. Tertiary Bronchus

a. Right Lungs

Upper Lobe

In present study of 32 right lungs, in 21 specimens (65.6%), the right superior lobar bronchus divides into three segmental bronchi - the apical, posterior and anterior. The apical segmental bronchus continues superolaterally twoards the apex of the lung, which it supplies and divides into sub-segmental bronchi. The posterior segmental bronchus supplies the posteroinferior part of the superior lobe, passess posterolaterally and slightly superiorly and divides. The anterior segmental bronchus runs antero-inferorirly to supply the rest of the superior lobe.

In 05 specimens (15.7%), the right primary bronchus divides into upper and lower divisions; the upper gives rise to apical, posterior and anterior segmental bronchi and then continues as the middle lobar bronchus that divides into lateral and medial segmental bronchi. The bronchus intermedius which is the continuation of the primary bronchus enters the lower lobe as inferior lobar bronchus [Fig No.35(i)].

In 03 other specimens (9.4%), the right principal bronchus divides into superior and inferior, divisions. The superior division again divides into superior lobar and middle lobar bronchi, where the superior lobar bronchus gives rise to apical, posterior and anterior segmental bronchi and the middle lobar bronchus gives rise to lateral and medial segmental bronchi [Fig No.35(ii)].

In one specimen (3.1%), the right principal bronchus gives off upper division and continues as the intermedius bronchus which is rudimentary and the upper division again divides into two, one gives rise to apical, posteior and anterior segmental bronchi which supplies the superior lobe and the lower division again divides into upper and lower the upper one dividing into three - one supplies the lateral segment and the second supplies the medial segment of the middle lobe and the third was found to supply the superior (apical basal) segment of the inferior lobe; the lower one dividing into medial basal, anterior basal, posterior basal and lateral basal segmental bronchi of the inferior lobe [Fig No.35 (iii)].

In one more specimen (3.1%) the superior lobar bronchus divides into two the apico-poserior and anterior segmental bronchi instead of three which is

the usual pattern. The apico posterior again divides into apical and posterior [Fig No.35(iv)].

In another one speicmen (3.1%), a pattern of trifurcation in which all the apical, posterior and anterior segmental bronchi arise from a common origin from superior lobar bronchus of less than 01 cm length supplying the right superior lobe [Fig No.35(v)] (Table No.7).

MIDDLE LOBE

In 30 specimens (93.7%), the middle lobar bronchus divided into lateral and medial segmental bronchi and in 02 specimens [Fig No.36 and 37] 06.3% accessory segmental bronchus was seen arising from the middle lobar bronchus before it bifurcates into lateral and medial segmental bronchi (Table No.8).

Among these two, in one right lung, the middle lobar bronchus divides into three segmental bronchi supplying lateral and medial segments of the middle lobe and the third supplying the superior segment of the inferior lobe [Fig No.37].

In another right lung, an accessory segmental bronchus arising from the middle lobar bronchus supplies the medial segment of the middle lobe which receives two segmental bronchi [Fig No.36].

LOWER LOBE

In 30 right lung specimens, at or a little below the origin from the principal bronchus, the right inferior lobar bronchus gives off a large superior (apical basal) segmental bronchus posteriorly. This runs posteriorly to the

upper part of the inferior lobe. After giving off the superior segmental branch, the right inferior lobar bronchus descends posterolaterally. The medial basal segmental bronchus branches from its antero - medial aspect, and runs infero medially to a small region below the hilum. The inferior lobar bronchus continues downwards and then divides into an anterior basal segmental bronchus, which descends anteriorly, and a trunk that soon divides into a lateral basal segmental bronchus, which descends laterally, and a posterior basal segmental bronchus, which descends posteriorly [Fig No.38].

One right lung specimen (3.1%) showed the medial basal segmental bronchus arising from the posterior basal segmental bronchus [Fig.No.39].

An other right lung specimen (3.1%) - (Fig No.40] showed a common origin of the segmental bronchus of antero - medial which subsequently divides into anterior basal and medial basal segmental bronchi instead of arising separately from the inferior lobar bronchus (Table No.9).

Apart from the normal segmental brinchi arising from the inferior lobar bronchus in 3 cases just beneath the superior segmental bronchus arrics the sub-superior segmental bronchus [Fig No.41 and 42]. Which is distributed to the region of the lung between the superior (apical basal) and posterior basal segments.

LEFT LUNG

Upper lobe

Normally the superior division of the left superior lobar bronchus ascends about o1 cm, gives off an anterior segmental bronchus, continues a further 01 cm as the apico posterior segmental bronchus and then divides into apical and posterior branches [Fig No.43a] The inferior descends anterolaterally to the antero inferior part of the left superior lobe (the lingula) and forms the lingular bronchus, which divides into superior and inferior lingular segmental bronchi.

In the present study of 32 left lung specimens, in 28 specimens (81.3%) the same pattern was observed [Fig.No.43].

In two specimen there was no lingular bronches from superior lobar bronchus instead it arises from Inferior lobar bronchus [Fig No.44 and 45].

In one specimen [Fig No.46] (3.1%) a common stem for anterior and posterior segmental bronchi was found.

In one specimen [Fig No.47] (3.1%) there was an division of left principal bronchus into superior and inferior lobar bronchi (Table No.10).

LOWER LOBE

In the inferior lobe, the superior (apical basal) segmental bronchus arises from the inferior lobar bronchus posteriorly about 01 cm from its origin. After a further 1 - 2 cms, the inferior lobar bronchus divides into an antero - medial

and a posterolateral stem. The antero-medial stem divides into medial and anterior basal segmental bronchi. The later divides into posterior and lateral basal segmental bronchi [Fig No.48].

In my present study of 32 left lung specimens, 27 (84.4%) showed the normal pattern where apical basal, antero-medial and postero-lateral basal segmental bronchi arise from the inferior lobar bronchus, the latter two further divide into medial and anterior basal and posterior and lateral basal segmental bronchi [Fig No.48].

In one specimen [Fig No.49] (3.1%), the left principal bronchus is single and does not divide.

In one specimen [Fig No.50] (3.1%), it showed the absence of the medial basal segmental bronchus, in which, only four segmental bronchi namely the superior, anterior basal, posterior basal and lateral basal were present.

Another specimen [Fig No.51] (3.1%) showed the origin of lateral basal segmental bronchus from the inferior lobar bronchus separately.

In 2 specimens (6.3%) lingular bronchus arises from inferior lobar bronchus (Table No.11).

VI. CLINICAL STUDY

Abnormalities may involve the tracheo - bronchial tree, lung parenchyma, and pulmonary vasculature. Defects may be so severe as to result in still birth or profound neonatal respiratory distress with cyanosis. Other manifestations assume a more insidious course. Knowledge of pulmonary embryology and historical contributions relating to these disorders allow a logical diagnostic and therapeutic approach in most instances.

All the clinical study were by computer tomographic scanning and only the necessary cases were exposed to the chest radiographs of postero - anterior and lateral views. Some were posted for bronchoscopy in which bronchial lavage, bronchial brush and bronchial wash being performed. In one case, ultra - sonography guided trans - thoracic needle biopsy was performed.

With the obtained histopathological reports, correlated the clinical and radiological findings to arrive at a proper diagnosis.

With the diagnosis, all the cases were scheduled in the tabular column as follows :-

i. Type of diseases

ii. Segmental involvement and lobar involvement and

iii. Surgical management.

TABLE No - 13

Sl. No.	Name of the Patients	Age in Yrs.	Sex M/F	Diagnosis	Segment / Lobe involved	X-ray / Scan (CT)	Surgical Management
1.	Mr.Thangaraju Fig No.52	53	M	Distal obstructive pneumonitis	Right upper lobe - posterior segment	xray lat view	Segmental resection
2.	Mr.Ravi Chandran Fig No.53	36	M	Bronchogenic Cyst	Right Upper lobe	CT Scan SC+IV row 1&2	Resection of the Lesion
3.	Mr.Periya Thambi Fig No.54	60	M	Mass Lesion	Right Upper lobe	CT Scan SC+ III row 3&4	Lobar resection
4.	Mr.Naganathan	39	M	Necrotising pneumonia - Intra lobar sequestration	Right lower lobe - posterior basal segment	CT S / SC + V row	Segmental resection
5.	Mr.Sundaramurthy Fig No.55	35	M	Consolidation with acquired bronchictasis	Right lower lobe	CTS / SC+ IV row-3&4	Lobar resection
6.	Mr.Thomas	55	M	Bronchiectasis Sicca	Left Upper lobe	CTS / SC + III row	Resection of the bleeding segment it not controlled even after embolisation
7.	Mr.Kannan Fig No.56	65	M	Mass Lesion	Left Upper lobe	CTS / SC + III row	Lobar resection
8.	Mr.Arul Fig No.57	55	M	Mass Lesion	Left Upper lobe and lingula	CTS / SC + II 4th & III, 1, 2 & 3	Lobar resection
9.	Mr.Patchiappan Fig No.58	66	M	Lung Abscess	Left Lower lobe	CTS / SC + IV row 3 & 4	It unresolved with medical line of management segmental resection / lobectomy
10.	Mrs.Saraswathy Fig No.59	30	F	Bilateral multiple cystic bronchiectasis	Both (right & left) lower lobes	CTS / SC + IV row	Lung Transplantation if necessary

NB : CTS - Computer Tomographic Scanning
SC - Scout Film

VIII. HISTOLOGICAL ALTERATION OF THE BIONCHO-PULMONARY TREE

Trachea

In the histological section, the lining opithelium, pseudostratified ciliated columnar epithelium interspersed with goblet cells [Fig No.62] lying on a basal lamina was observed. Deep to basal lamina is the lamina propria containing elastic fibres and a submucosa of connective tissue. External to this is the imperfect ring of hyaline cartilage [Fig No.63] covered by perichondrium. Behind, where the cartilage is deficient, fibro-elastic and smooth muscle fibres are seen [Fig No.60(i), 60(ii) and 61].

EXTRA PULMONARY BRONCHUS

The lining epithelium is pseudo - stratified ciliated columnar epithelium. The cartilaginous plates are irregular [Fig No.64 and 65]. Lymphoid tissue is seen [Fig No.66].

INTRA - PULMONARY BRONCHUS

The living epithelium is pseudostratified ciliated columnar epithelium. This lamina propria of fine connective tissue and a few lymphocytes. Thin layer of muscles surrounds the lamina propria and separates if from the sub-mucosa and this submucosa contains seromucous bronchial glands [Fig No.67]. Plates of hyaline cartilage surround the bronchus which progressively form the less and less of the bronchial wall and the perichondrium covers each cartilage plate [Fig No.68]. Smooth muscle of intra - pulmonary bronchus is not attached to the bronchi. In segmental bronchus, the smooth muscle is arranged in a spiral layer [Fig No.70].

COMPARATIVE ANATOMY

The lungs of sheep and goats are similar in gross but show a lesser degree of population. The pattern in sheep often varies between parts of the lung, some of which may clearly show the connective tissue septa through the visceral pleura, while others may be almost unmarked.

The lungs of horses show almost no lobation and vary inconspicuous lobulation externally; those of ruminants and pigs are conspicuously lobated and lobulated [though not uniformly in sheep and goats], whereas those of carnivores are very deeply fissured into lobes but show little external evidence of lobulation.

In goat, a separate bronchus for the right cranial lobe is detached a few centimeters before the bifurcation of trachea [Fig No.71 and 71(i)].

STRUCTURE OF TRACHEA:

The trachea is composed of an outer fibrous adventitia, cartilaginous rings, a sub mucous coat and mucous membrane. The outer fibrous layer may possess some longitudinal muscle fibres on the dorsal wall. The cartilaginous rings are of hyaline in nature. The sub mucous coat has a good number of serous and mucous glands, occasionally lymphoid follicles and plenty of elastin fibres. The mucous membrane is composed of pseudo stratified ciliated columnar epithelium.

The most common anomalies are the pulmonary hypoplasia, bronchial hypoplasia, accessory lungs, pulmonary cysts and abnormal lobation.

DISCUSSION

An extensive study on broncho - pulmonary tree was previously done by many authors. With due respect, I compare and quote the present study on 32 pairs of lung specimens with those of the eminent workers.

I. NORMAL PATTERN [Fig No.72 (i) to (iv)]

G.J. Romanes (1964), D.J.Dr.Plessis (1975), Bailey and Love (1977), Davidson (1977), T.S. Ranganathan (2003), Gray (2005), and Keith L. Moore (2006) say that the right lung has one oblique fissure and a horizontal fissure dividing it into three lobes and the left lung has one oblique fissure and two lobes.

The present study coincides with the above authors having 03 lobes divided by oblique and horizontal fissures in 90.6% of right lung specimens and in left lung specimens 02 lobes are present in 93.8% separated by an oblique fissure.

II. PULMONARY APLASIA AND HYPOPLASIA

* **Landing B.H. and Wells T.R. (1973)**; Presented a case in which 2 months old infant had pulmonary hypoplasia.

* **Asim Kumar Datta (2000)**; states that in renal agenesis bronchial branching is reduced resulting in pulmonary hypoplasia which suggests direct renal factor which is essential for the lung development.

* **I.B. Singh (2001)** Says that one lung or one of its lobes and associated bronchi may fail to develop or may remain under developed.

* **William J. Larsen (2002)** quotes that when the normal branching pattern is disrupted less severely it results in reducing the number of pulmonary segments resulting in pulmonary hypoplasia.

* **Keith L. Moore and T.V.N. Persaud (2005)** state that the lung hypoplasia is characterized by a markedly reduced lung volume.

In the present study of 32 pairs of lung specimens, hypoplasia of the left lung was found in two specimens, 6.2%.

III. FISSURES

a. Right Lung

Dandy W.E. Jr. (1978) stated that the frequency of in complete fissures in right lung in different series ranges from 12.5% to 73% for the major (oblique) fissures and from 60% to 90% for the minor (Horizontal) fissure.

In present study the frequency of the incomplete minor (horizontal) fissure was observed only in 09.37% in right lung specimens which is very less compared to the study of Dandy W.R. Jr.[Table No.14].

b. Left Lung

Boyden E.A. (1949a) found a transverse fissure in left upper lobe in 8 of 100 adult specimens (8%) separating the middle lobe from the superior lobe. He says that usually this fissure corresponds to the intersegmental plane between the lungular and the remainder of the upper lobe and some times the fissure does not represent a true separation of the lungular lobe, since the portion demarcated by it may contain anterior segmental bronchi.

Austin J.H. (1986) described a horizontal fissure present in left lungs in 8 - 18% of people which is analogous to the horizontal fissure of right lung separating the lungular from the rest of the left upper lobe.

Inderbir Singh (2001) states the presence of transverse fissure resulting in three lobes in the left lung.

Gray (2005) quotes that a horizontal fissure is present in the left lung and is a common variant seen in 10% of the patients.

The present study shows the presence of a horizontal fissure in 06.3% of the specimens in the upper lobe of left lungs which is slightly lower than the result of Austin J.H. and Gray [Table No.15].

c. Accessory Horizontal Fissure

Deve M.F. (1900) observed a fissure on the diaphragmatic surface of the lower lobe of right lung, sharply curved towards the vertebral border of the lung which defined the `cardiac lobe' or medial basal segment of lung. He identified this fissure in 35% of cases.

He also reported a partial fissure between the superior and basal segments of the lower lobes, as occurring 40 times on the right and 14 on the left in 180 infants.

Proto A.V. Speck man J.M. (1979) stated that the superior accessory fissure separates the superior (apical basal) segment of a lower lobe from the basal segments.

Godwin J.D., Tarver R.D (1985) explain that the inferior accessory fissure usually incompletely separates the medial basal segment from the rest of the lower lobe.

Inderbir Singh (2001) states that occurrence of a transverse fissure which separates the medial basal segment and superior segment of the lower lobe from other segments of lower lobe.

Gray (2005) states that presence of an inferior accessory fissure, which separates the medial basal segment from the remainder of the lower lobe and a superior accessory fissure which separates the apical segment of the lower lobe from the basal segments.

The present study revealed the presence of an accessory horizontal fissure in the lower lobe of the right lung, the part superior to the fissure was supplied by the lateral and posterior basal segmental bronchi and the portion below by the (superior) apical, medial and anterior basal segmental bronchi and the frequency 03.1%. Indistribution, the present study varies from the study of Deve, Proto and Speckman, Godium, Tarver, I.B. Singh and Gray.

AZYGOS LOBE

Etter L.E (1947) after an elaborate study of 50,000 consecutive roentgenograms of the thorax, states that the striking abnormality in lobation is the presence of any azygos lobe (lobe of wrisberg), found to have an incidence of 0.26%.

D.J.Du.Plessis (1975) mentions three varieties of super numerary lobes of lung. One is the lobe of azygos vein, and the other two are upper azygos (accessory) lobe and lower azygos lobe which are not assocaited with ayzgos vein.

Inderbir Singh (2001) states the upper and lower azygos lobe are the common variations.

Keith L. Moore (2006) quotes the more common "accessory" lobe is the `azygos lobe'.

As per the above scientists study, in the present study the azygos lobe was observed in the right upper lobe in 2 specimens (6.3%) and in the lower lobe in 1 specimen (3.1%).

Gillaspie, C., Miller L.I. and Baskin, M., (1916) told the anomalies of lobation of the lungs may be produced by fusion of adjacent lobes to obliterate a fissure, or by the occurrence of abnormal fissures, or by the aplasia or agenesis of a part of a lung.

BRANCHING PATTERN

Normal Pattern :

RIGHT LUNG

Gray (2005) and Keith L. Moore (2006) say that right principal bronchus gives rise to superior lobar bronchus and continues as the intermediate stem bronchus. This intermediate stem bronchus after giving rise to the middle lobar bronchus continues as the inferior lobar bronchus.

They also say that the superior lobar bronchus gives rise to apical, posterior and anterior segmental bronchi.

The middle lobar bronchus divides into lateral and medial segmental bronchi.

The inferior lobar bronchus gives origin to apical basal, medial basal, anterior basal, lateral basal and posterior basal segmental bronchi.

In the present study, the right principal bronchus gives rise to superior lobar bronchus and continues as the intermediate stem bronchus which in turn divides into middle and inferior lobar bronchi in 23 specimens (71.9%)

Mannes G.P., Vander Jagt E.J., Wonters B, et al., [1989] quote that there may be a common origin of the right upper and middle lobar bronchi.

Gray [2005] quotes that a common origin of right upper and middle lobar bronchi is a variant.

The present study also reveals that presence of common origin of right upper lobar and middle lobar bronchi in 9 specimens out of 32 right lung specimens which was also reported by **Mannes G.P., Vander Jagt E.J., Wonters, BN., et. al., and Gray**.

In the present study, the superior lobar bronchus gives rise to apical, posterior and anterior segmental bronchi in 21 specimens [65.6%] which coincides with the statement of **Gray [2005] and Keith L.Moore [2006].**

In 9 specimens in the present study, the middle lobar bronchus also arises from superior lobar bronchus on the right side as reported by **Mannes, G.P. Vander Jagt, E.J., Wonters, B., and Gray.**

Boiden E.A., and Scannell T.G., [1948] reported that the manner of branching of superior lobar bronchus was found to be a bifurcation in 54%

Bloomer W.E., Ziebow D.A., and Hales M.R., [1960] found bifurcation in 48% of cases.

In present study, in one specimen [3.1%] apical and posterior segmental bronchi arise by a common stem instead of arising separately from the superior lobar bronchus and this pattern is bifurcation as reported by **Boyden E.A., and Scannell T.G.,** but only in 3.1% it was found.

Boiden E.A., and Scannel T.G., [1948] revealed that the right upper lobar bronchus gives rise to three segmental bronchi (trifurcation) about 46% of cases.

Bloomer W.E., Zeibow D.A., and Hales M.R., [1960] reported trifurcation in 52%.

In the present study, the superior lobar bronchus divides into three segmental bronchi namely the apical, posterior and anterior segmental bronchi (trifurcation) in 68.7% of cases which is higher than the study of **Boyden E.A., and Scannel T.G., [1948] and Bloomer W.E., Ziebow D.A., and Hales M.R. [1960]** [Table No.16].

In the present study the middle lobar bronchus dividing into lateral and medial segmental bronchi in 30 right lung specimens [93.8%] which was a normal pattern as described by **Gray [2005] and Keith L. Moore [2006]**.

Boyden E.A., and Hamre C.J. [1951] say that in 2 – 3% of cases trifurcation occurs instead of bifurcation into lateral and medial segmental bronchi of the right middle lobar bronchus.

Hamilton, Boyd and Mossman [1972] explain that occasional monopodial branchings of the stem bronchi account for the accessory bronchi and lobes often found in the adult lungs. [Table No.17]

In the present study, the middle lobar bronchus divides into three segmental bronchi instead of two-the lateral and medial in 6.3%. Among these two, in one specimen, the accessory segment supplies the middle lobe and in other, it supplies the apical basal segment of the right inferior lobe.

In the present study, the inferior lobar bronchus giving rise to superior, medial anterior, lateral and posterior basal segmental bronchi was found in

[93.8%] 30 specimens which is the normal pattern observed by **Gray [2005] and Keith L.Moore[2006].**

In the present study, in one specimen, medial based was arising from the posterior basal segment (3.1%) and in one specimen, there was a common origin of anterior and medial basal segments (3.1%).

Bailey and Love., [1977] say that failure of a main bronchus to develop, results in unilateral agenesis whilst failure of a lobar bronchus to develop produces lobar agenesis.

I.B. Singh [2001] says that one lung or one of its lobes and associated bronchi may fail to develop or may remain under developed.

TSUNEZUKA and Colleagues [2002] reported the absence of a right upper lobar bronchus in an elderly woman.

Landing B.H., and Wells T.R., [1973] quoted the absence of the right middle lobar bronchus.

Fierguson and Neuhausen [1944] have reported a patient with only a right upper lobar bronchus with the absence of a middle lobar and lower lobar bronchi during bronchescopy.

Atwell [1967] described the absence of four lobar bronchi, one of the right upper lobe and three of the left upper lobe in a series of 1200 consecutive, complete, and bilateral bronchograms – an overall incidence of 0.16%.

In the present study, absence of upper, middle or lower lobar bronchus was not observed in any of the right lung specimens.

Berg R.M., Boyden K.A., and Smith F.R., [1949] found that in addition to a sub-superior bronchus proper arising posteriorly from the left inferior lobar bronchus, an accessory sub-superior, arising as a single bronchus of the posterior basal in 71% and as two branches in 13% and an accessory sub-superior from the lateral basal in 67%

Fierry R.M. Jr and Boyden E.A., [1951] in 100 cases investigated by them, found the superior segment of right lower lobe to be supplied exclusively by a Sub-superior bronchus proper in 16% and in 39% exclusively by one or more accessory sub-superior bronchi from the posterior basal bronchus.

D.J. Du Plessis [1975] describes a super-numerary bronchus found in 50% of cases which is called the sub-superior bronchus.

Gray [2005] says that in more than half of all right lungs a sub-superior (sub-apical) segmental bronchus arises posteriorly from the right inferior lobar bronchus 1.3 cms below the superior segmental bronchus, and is distributed to the region of lung between the superior and posterior basal segments.

The present study also shows the presence of sub-superior segmental bronchus arising pasteriorly from the right inferior lobar bronchus in 9.4% coinciding with Berg, Boyden and Smith, and Gray in the occurrence but for the side, this study coincides with gray as he says that the sub-superior arises posteriorly from the right inferior lobar bronchus. (Table No.18).

Thus, the present study is in lesser incidence when compared to the above authors whereas on the left side it is not found in the present study.

LEFT LUNG

According to **Gray [2005] and Keith L. Moore (2006),** the left primary bronchus divides into superior and inferior lobar bronchi. The superior lobar bronchus divides into upper and lower divisions. The upper division gives rise to anterior segmental bronchus and apico posterior division which in turn gives rise to apical and posterior segmental bronchi. The lower division divides into superior and inferior lingular segmental bronchi.

The inferior lobar bronchus gives origin to apical, antero-medial stem and postero-lateral stem where these divide into medial basal and anterior basal, lateral basal and posterior basal segmental bronchi respectively.

Chummy S. Sinnathamby [1999] presents that there are typically ten broncho pulmonary segments in each lung in which same segmental bronchi may share a common stem i.e. apico-posterior in left upper lobe. In the left lower lobe, the medial and anterior basal segments and the lateral and posterior basal segments arise from common stem bronchi which subsequently subdivide.

Boyden E.A. and Hartmann [1946] have shown the variants in the upper division of the upper lobar bronchus of the left lung as a single bifurcation of the superior division branches into apical-posterior and anterior segmental bronchi, about 74%..

T.S. Ranganathan (2003) explains that the left lung has the apico posterior segment thus reducing the number of total segments from 10.

In the present study, the same pattern of division of left superior lobar bronchus which is similar to the study of **Gray, Keith L. Moore, Chummy S. Sinnathamby, Boiden and Hartmann and T.S. Ranganathan** was observed in 28 cases (87.5%).

According to **Boyden E.A. and Hartmann(1946),** the bifurcation of the superior bronchus into apical-posterior and anterior segmental bronchi about 74% as a variant.

According to **T.S. Ranganathan (2003),** because of apico posterior segment in the left upper lobe, the total number of segments in the left lung is reduced from 10.

Whereas, according to **Gray (2005), and Keith L.Moore (2006),** the superior lobar bronchus divides into superior and inferior divisions. The superior division gives an anterior segmental bronchus and an apico-posterior division which inturn divides into apical and posterior segmental bronchi, making the total segments in the left lung as 10 segments which they describe as normal pattern.

In the present study in one specimen, anterior and posterior segmental bronchi (3.1%) arise by a common stem which was not reported by any of the authors.

In one specimen, there is an absence of all the segmental bronchi from superior lobar bronchus (3.1%).

The segmental bronchi of the lingular lobe instead of arising from the superior lobar bronchus arises from the inferior lobar bronchus in two specimens (6.3%) in the present study, this was not reported by any of the authors.

Storey C.F., and Marranooni, A.G., (1954) have reported the absence of a left lower lobe bronchus in a young adult man.

In the present study, in one specimen (3.1%) of the left lung, the superior lobar bronchus is absent and the principal bronchus continues as the inferior lobar bronchus.

In the present study, the inferior lobar bronchus after giving superior (apical basal) segmental bronchus divides into antero-medial and postero-lateral divisions which in turn divide into medial basal, and anterior basal, and lateral basal and posterior basal segmental bronchi in 28 specimens (84.5%) . Thus the present study coincides with the study of **Gray, Keith L.Moore, Chummy S. Sinnathamby, Boyden and Hartmann and T.S. Ranganathan.**

In two specimens, segmental bronchi supplying the lingular lobe arise from the inferior lobar bronchi (6.3%) which was not reported by any of the authors.

The lateral basal segmental bronchus directly arising from the inferior lobar bronchus in one specimen (3.1%).

Fierry R.M., Jr, and Boyden E.A.,(1951) state that in 20% of 50 specimens, the medial basal segmental bronchus was absent as such, its anterior branch arising from the anterior basal and its posterior branch from a sub-superior or posterior basal stem.

Davidson (1977) points out that there is no medial basal bronchus on the left side, and hence only 9 segments on left side

T.S. Ranganathan (2003) states that the left lung has 8 segments having the apico-posterior and anterior in the upper lobe and absence of medial basal segment in its lower lobe.

In the present study the medial basal segmental bronchus is absent in one specimen of the left lung (3.1%).

TRACHEO - BRONCHO-MEGALY

Woodring J.H. Howard R.S. and Rehm S.R. (1991) describes tracheobronchomegaly as a rare disorder of the lower respiratory tract characterized by marked dilatation of the trachea and bronchi, due to a congenital tissue defect resulting in a primary atrophy of the elastic and smooth muscle of the trachea and major bronchi. It occurs rarely in sublings and is associated with the Ehlers - Danlos syndrome and cutis laxa. Plain chest films will demonstrate the ectasia of the trachea and the mainstem bronchi. Bronchography will confirm the diagnosis if necessary and differenitate this lesion from acquired bronchiectasis.

In present study no such case is found.

BRIDGING BRONCHUS

Gonzalez - Crussi F, et al., (1976) report the rare anomaly - a so - called briding bronchus that arises from the left main stem bronchus and crosses the mediastinum to supply the right lower lobe and, at times, a portion of the middle lobe.

Star Shak, R.J., Sty J.R., Woods G, et al., (1981) isolated cases of the so - called "bridging bronchus" where the right lower lobe bronchus arises from the left main bronchus and crosses or "bridges" the mediastinum to reach the right lung and said that this anomaly is exceedingly rare.

Start Shak, R.J., (1981) and Bertucci (1987) reported a patient with the anomalous of brinding bronchus and they say that this condition may be frequently associated with either a pulmonary venous or a pulmonary artery abnormality.

In present study, this anomalous was not found.

BRONCHIECTASIS

Churchill E.D., et al., (1940) emphasized that bronchictasis typically has a segmental distribution affecting the lingular lobe and the basal segments of the lower lobe on the left, the middle lobe and the basal segments of the lower lobe on the right.

Firank W. Sell KE, (2005) quotes that bronchiectasis is an abnormal dilatation of the bronchi or bronchioles. It is believed to be secondary to failure of the mesenchyme to differenitate into cartilage and muscle. It results in a chronic, mildly productive cough with recurent pneumonia.

In the present clinical study it was noted in one female patient (Mrs.Saraswathy, 30 years of age) to have the predominant bilateral manifestations of (Multiple cystic) bronchiectasis involving middle and lower lobes in both lungs.

CONCLUSION

The present study included both (adult and foetal) cadaveric dissections with luminal casting, bronchogram pictures and clinical study.

The branching pattern of the broncho - pulmonary segments is recognised as an important anatomical tree is placing the diagnosis of any lesion in the lungs with its extent, the familiarity of which is an absolute need for the anatomists to teach, physicians to diagnose the lesions and the surgeons especially the cardio - thoracic surgeons while planning for and performing the procedure of pneumonectomy and lung transplantation from a simple segmental resection and draining of an abscess.

The extensive study of the lungs is relation to the size, number, fissures, lobes and the branching pattern of the bronchopulmonary tree under various method are concluded as follows :-

* In all the right lung specimens studied, the oblique fissure was present and the complete horizontal fissure was found in 90.6% and incomplete horizontal fissure in 9.4% dividing the right lung into upper, middle and lower lobes.

* Accessory horizontal tissue was present in 6.3% of right lungs, in these specimens four lobes are present.

* Was observed in left lung, the presence of oblique tissue in 93.8% and left lung is divided into two lobes.

* The horizontal tissue was present in 6.2% of the left lungs and in these specimens three lobes are present.

* Trachea divides into two principal bronchi in all specimens.

* In 71.9% superior lobar bronchus arises from the right primary bronchus, the latter then continues as bronchus intermedius which gives left middle and inferior lobar bronchi which is the normal pattern.

* The superior lobar bronchus divides into apical, posterior and anterior segmental bronchi in 65.6% of the specimens.

* Middle losar bronchus arises from the superior lobar bronchus and the intermediate bronchus continues as the inferior losar bronchus in 25%.

* The middle lobar and inferior lobar bronchi arise from the superior lobar bronchus and the intermediate bronchus is rudimentary in 3.1%.

* In left lung specimens, the primary bronchus divides into superior and inferior lobar bronchi in 96.9%.

* In 3.1% of specimens there is lobar and segmental bronchial agenesis.

* The left superior lobar bronchus dividing into apical, posterior, anterior, superior lingular and inferior lingular segmental bronchi in 87.5%.

* Absence of segmental bronchi to lingual from superior lobar bronchus in 6.3%.

* Common stem for anterior and posterior segmental bronchi in 3.1%.

* Absence of all segmental bronchi from superior lobar bronchus in 3.1%.

* The left inferior lobar bronchus dividing into apical basal, medial basal, anterior basal, lateral basal and posterior basal segmental bronchi in 84.4%.

* Medial basal segmental bronchus was absent in 3.1%.

* Segmental bronchi for lingula arising from inferior lobar bronchus in 6.3%.

* Absence of all the segmental bronchi from the inferior lobar bronchus in 3.1%.

* Lateral basal segmental bronchus arising from the inferior lobar bronchus in 3.1%.

* The frequency of number of broncho-pulmonary segments in right lung specimens are: 11 segments 3.1%, 10 + 1 segments

where the +1 denotes the presence of sub-superior segmental bronchus 9.4% and 10 segments 87.5%.

* The frequency of number of broncho-pulmonary segments in left lung specimens are:10 segments 93.8%m 09 segments 3.1% and 00 segments 3.1%.

"What the mind doesnot know,

the eyes will not see!"

Hence, a thorough knowledge of the anatomy of the bronchial tree is essential, not only for the diagnosis of many chest conditions, but for the planning and execution of the majority of pulmonary operations.

Also,

"Where there is a will,

there is a wish!

When there is a wish,

there is a way!!"

I believe that, ever there is a wish to have a will for the way, in understanding the anatomy of the broncho-pulmonary tree and its clinical significances - as the segmental architecture of the lungs is fairly uniform, infections and neoplastic processes are often localized to one or more adjacent segments and conservation of lung tissue is thus often possible in removal of the diseased areas.

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PULMONARY HYPOPLASIA

Fig No.17

Right Lung

Left Lung

Right Lung

Left Lung

Fig No.18

AZYGOS LOBE IN RIGHT LOWER LOBE

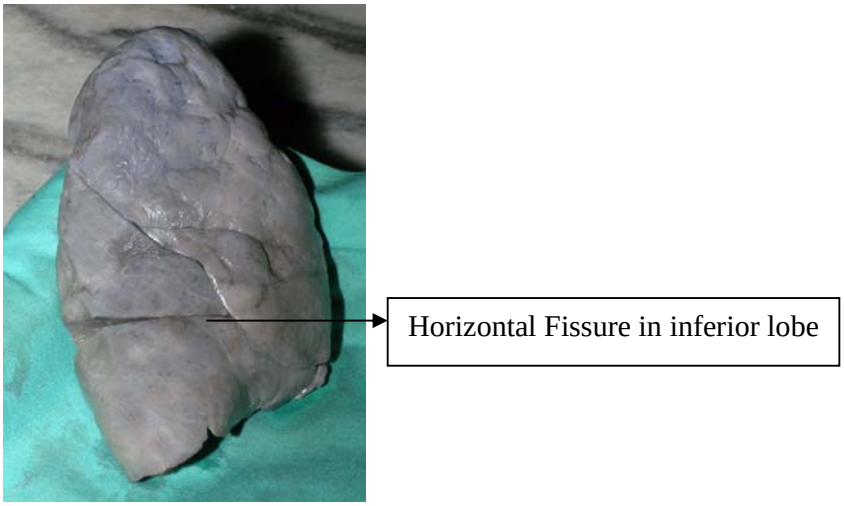
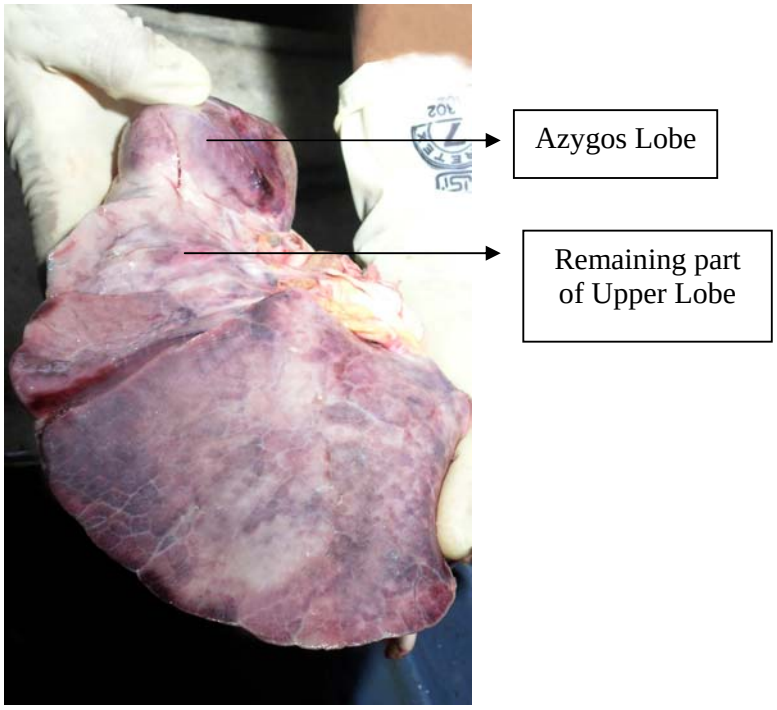


Fig No.28

AZYGOS LOBE IN RIGHT UPPER LOBE



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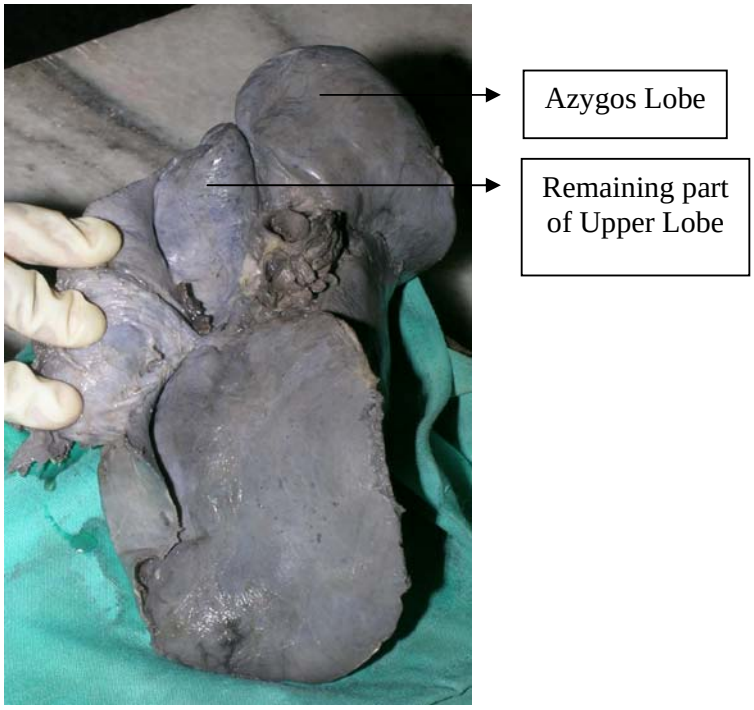


Fig No.27

RIGHT LUNG - IN COMPLETE HORIZONTAL FISSURE

Fig No.20

Fig No.21

Fig No.22

FIG NO. 1 PAIR OF LUNGS IN SITU

Fig No.1 (i)

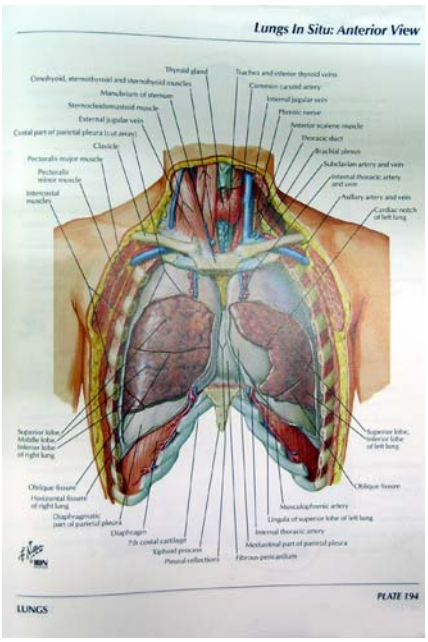


Fig No.1 (ii)

Fig No.1 (iii)

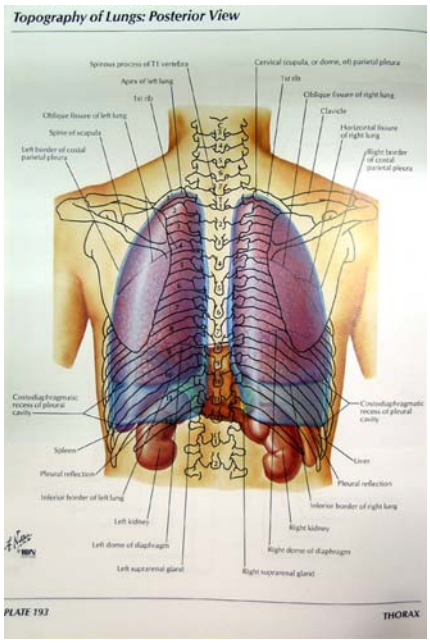


Fig No.1 (iv)

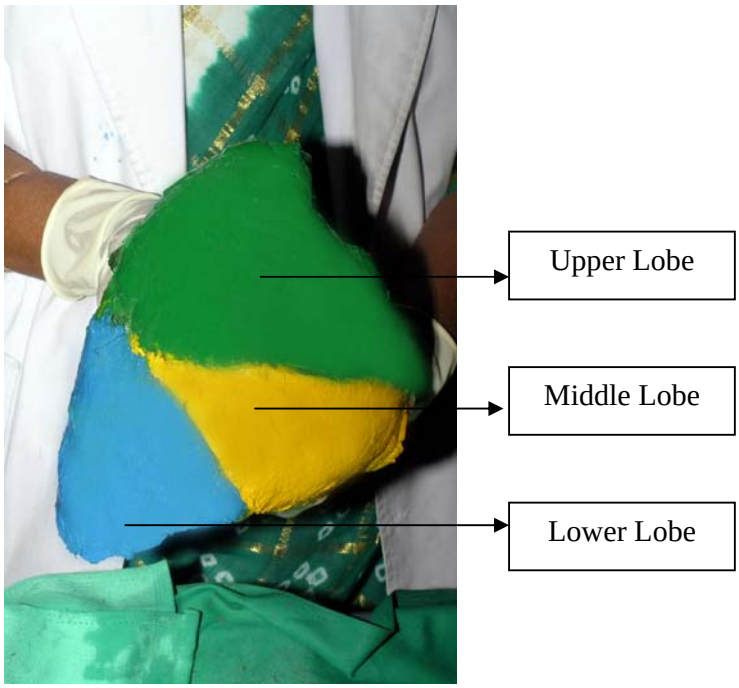


Fig No. 2 ANTERIOR VIEW OF RIGHT

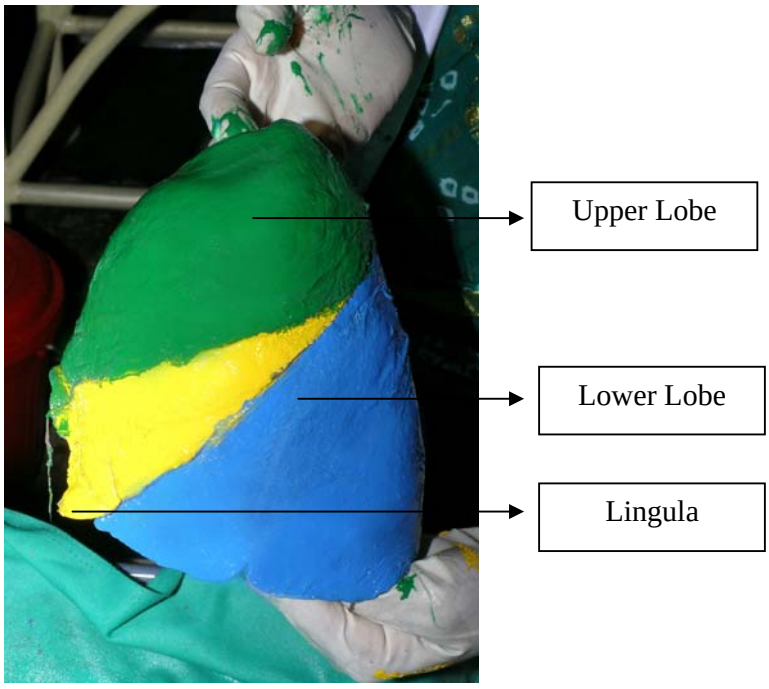


Fig No.3 ANTERIOR VIEW OF LEFT LUNG

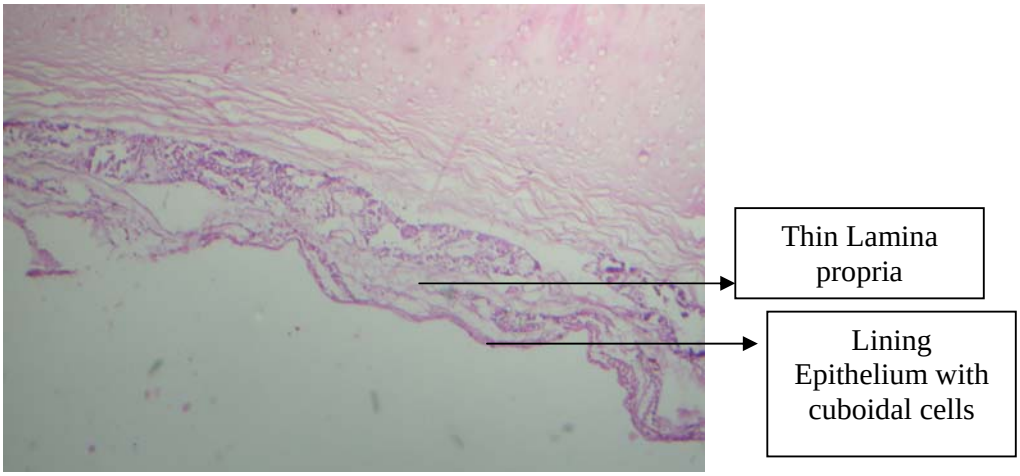


Fig No.69

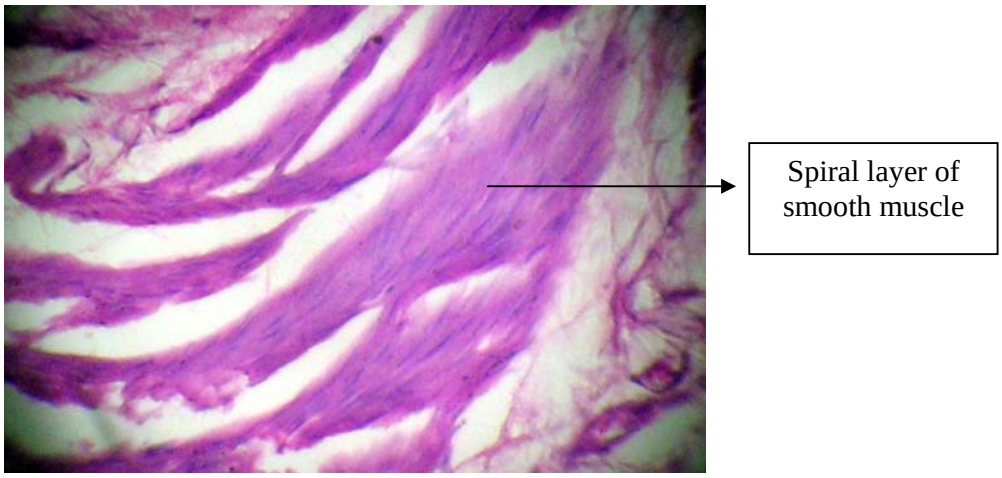


Fig No.70

INTRA PULMONARY BRONCHUS

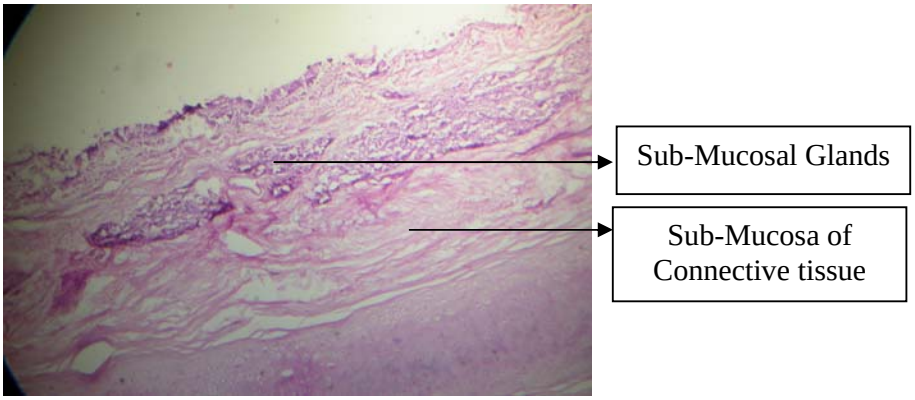


Fig No.67

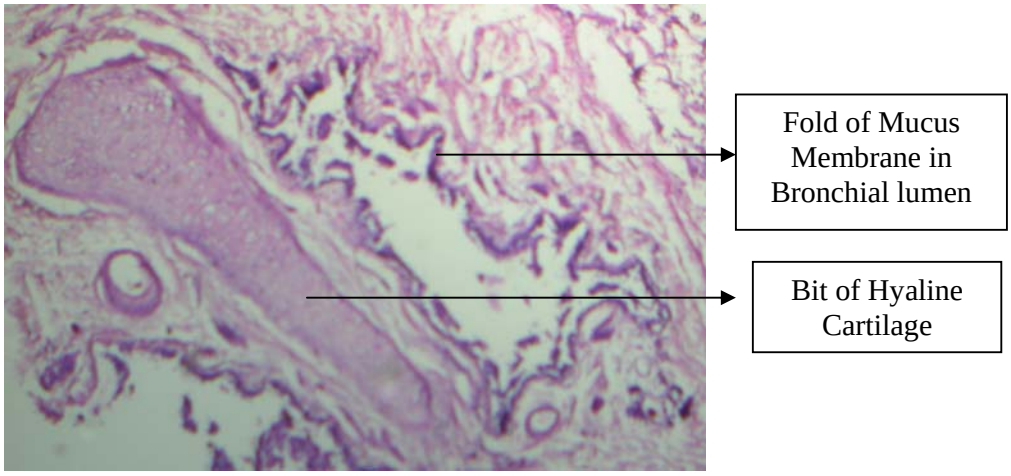
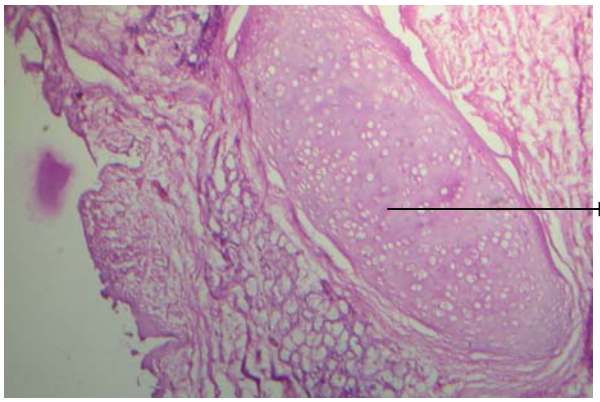


Fig No.68



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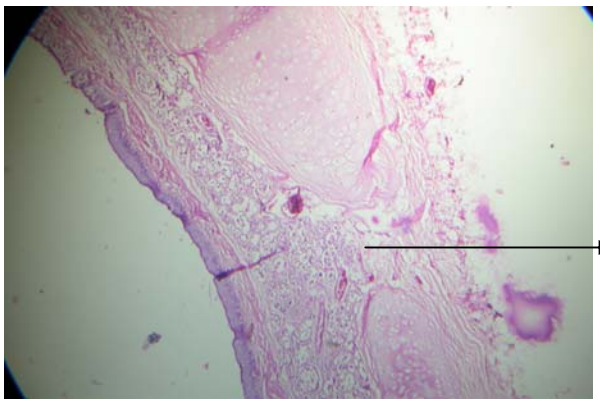


Fig No.65

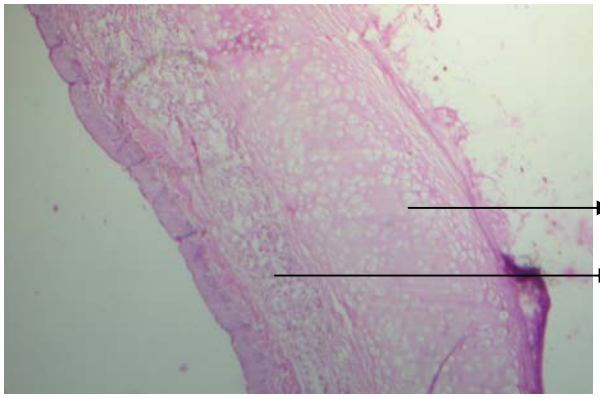


Fig No.66

HISTOLOGY OF BRONCHO PULMONARY TREE

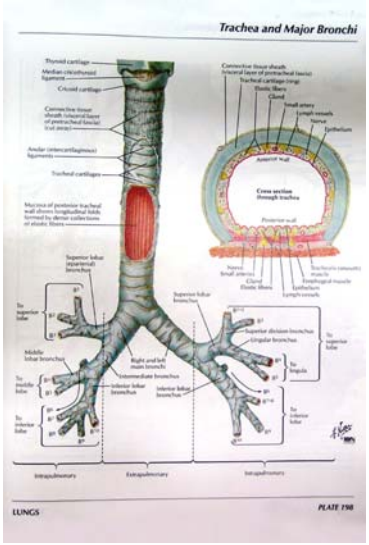


Fig No.61

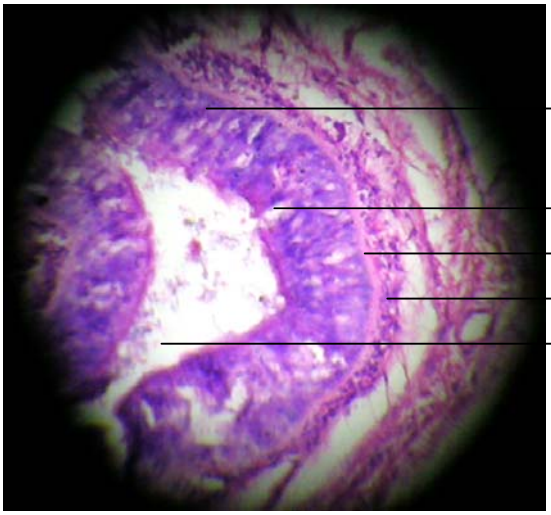


Fig No.62

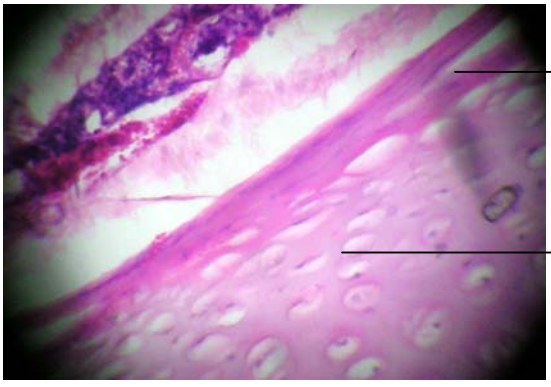
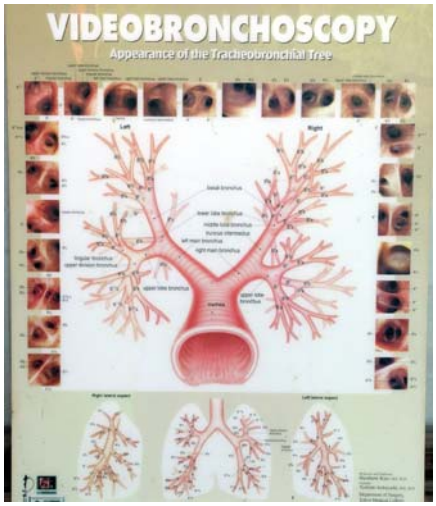


Fig No.63



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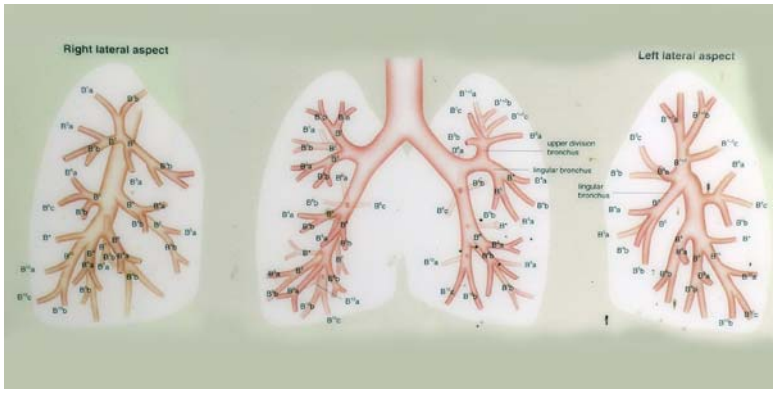


Fig No.16a

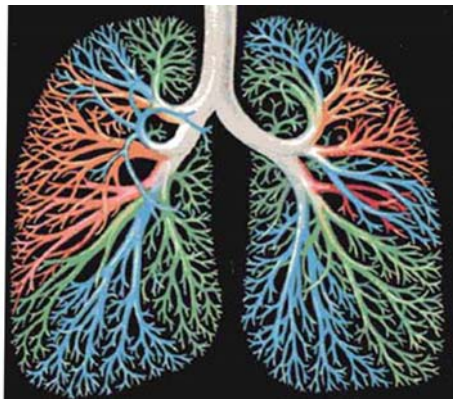


Fig No.16b

BRONCHOSCOPIC VIEW OF BRONCHO PULMONARY TREE

Fig No.60 HISTOLOGY OF INTRAPULMONARY BRONCHUS (TRANSVERSE SECTION)

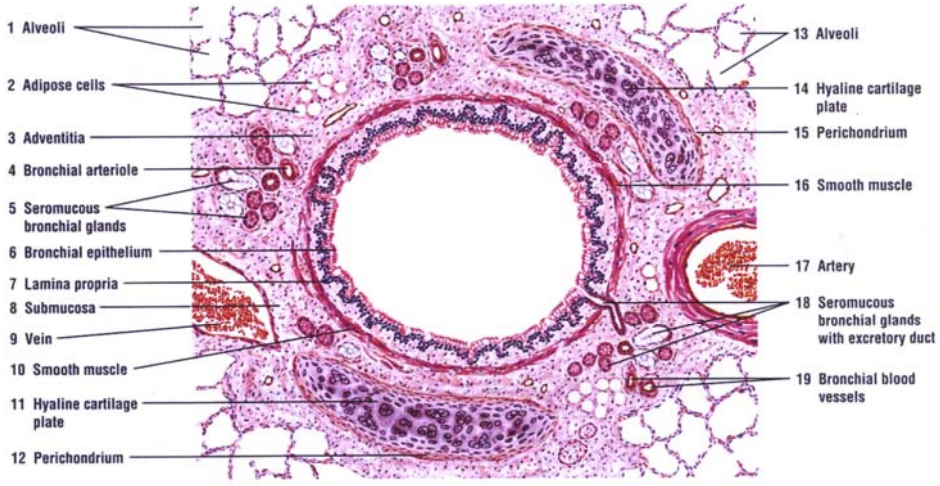


Fig No.60(i)

HISTOLOGY OF TERMINAL BRONCHIOLE (TRANSVERSE SECTION)

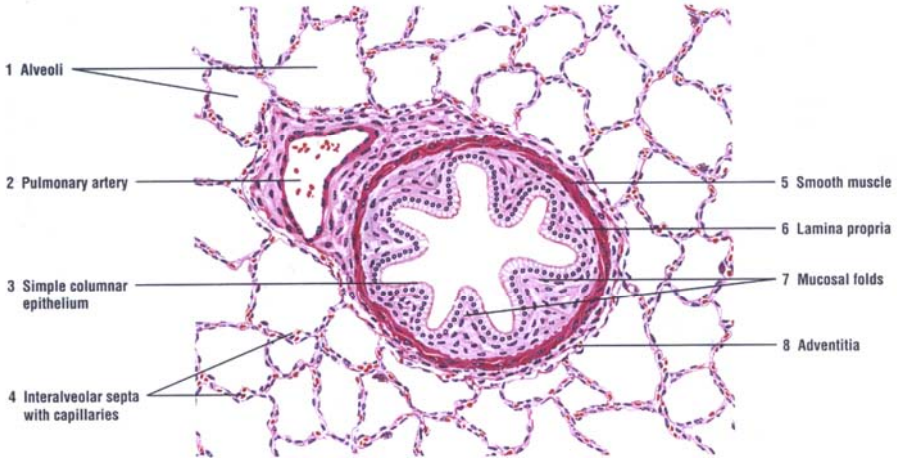


Fig No.60(ii)

Fig No.71 TRACHEO - BRONCHO - PULMONARY TREE PATTERN IN GOAT LUNGS

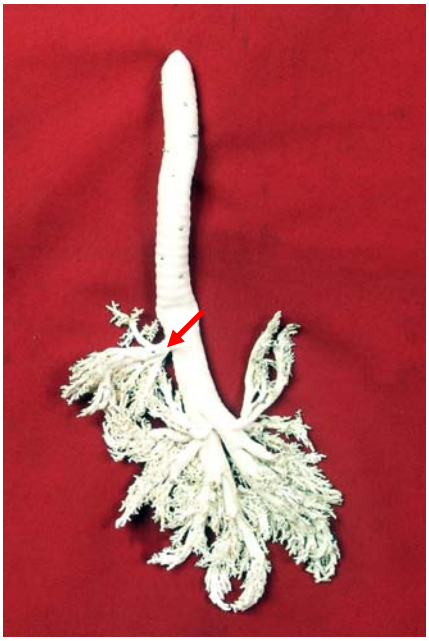


Fig No.71(i)

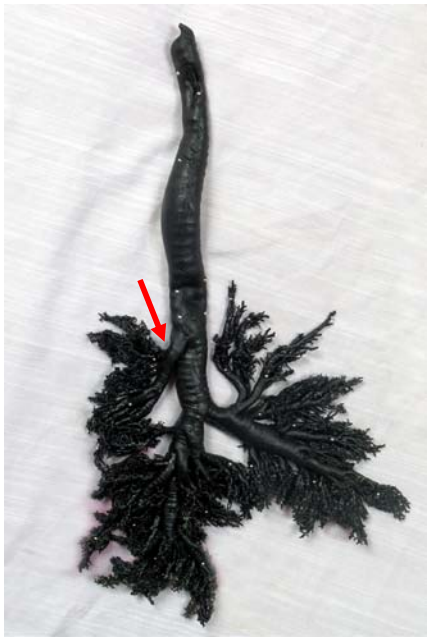


Fig No.71(ii)

LUMINAL CASTINGS OF LUNGS OF TWO GOATS

Fig No.14

Fig No.15

MATERIALS NEEDED FOR THE DISSERTATION

CAMPUS WHERE DISSERTATION PERFORMED

INSTITUTION WHERE DISSERTATION PERFORMED

DISSECTION HALL

DISSECTED VIEW OF A PAIR OF LUNGS WITH COMMON ORIGIN OF SEGMENTAL BRONCHI

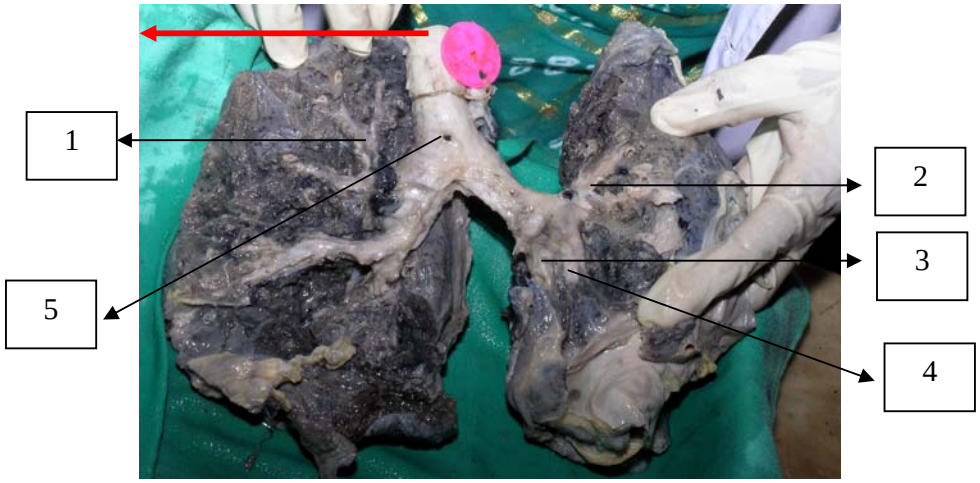


Fig No.38

1. Apicoposterior stem of Right Upper Lobe
2. Apicoposterior stem of Left Upper Lobe
3. Antero - medial stem of Left Lower Lobe
4. Postero- lateral stem of Left Lower Lobe
5. Lymphnode

DISSECTED VIEW OF AZYGOS LOBE OF RIGHT LUNG

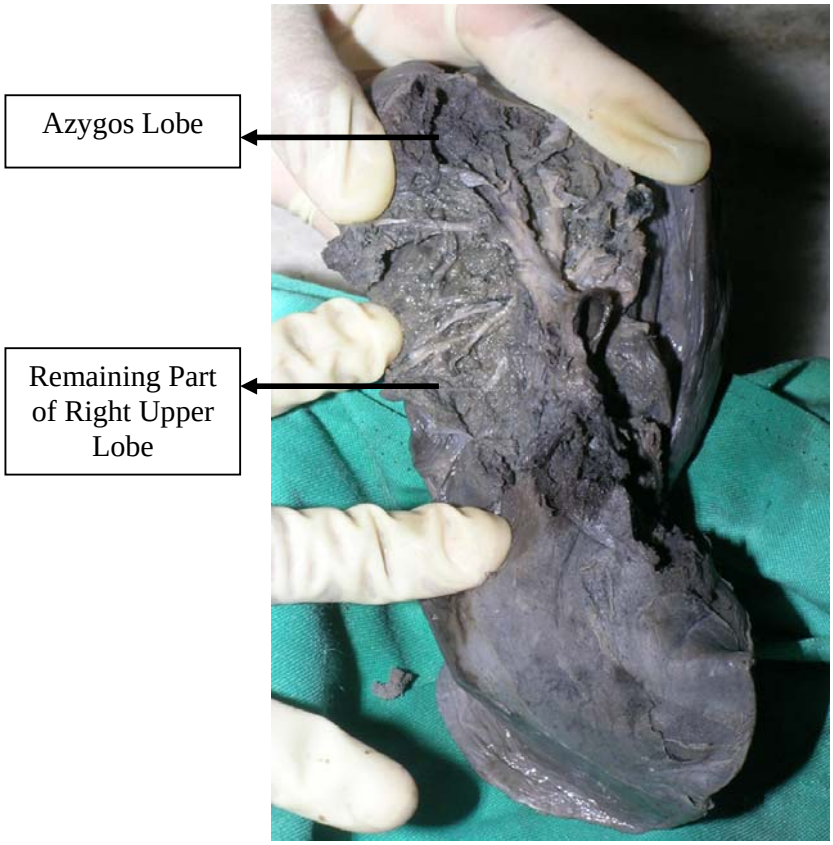
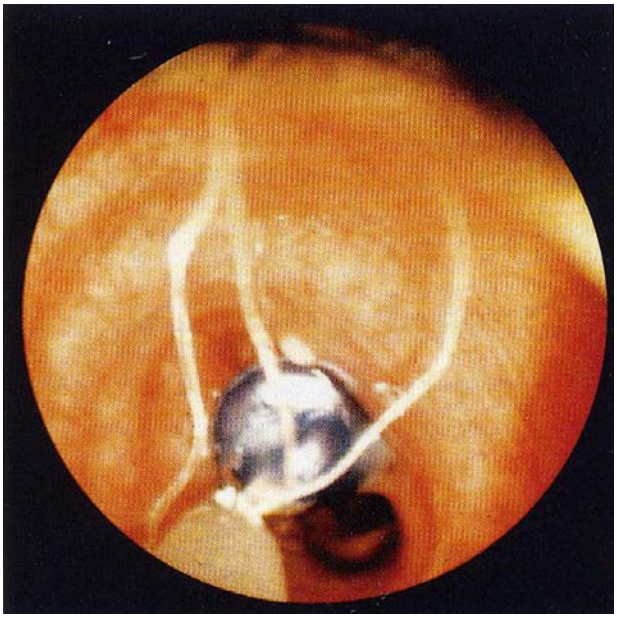


Fig No.29

Fig No.4 BRONCHOSCOPIC VIEW OF FOREIGN BODY BRONCHUS



RIGHT LUNG WITH HORIZONTAL FISSURE IN ITS INFERIOR LOBE

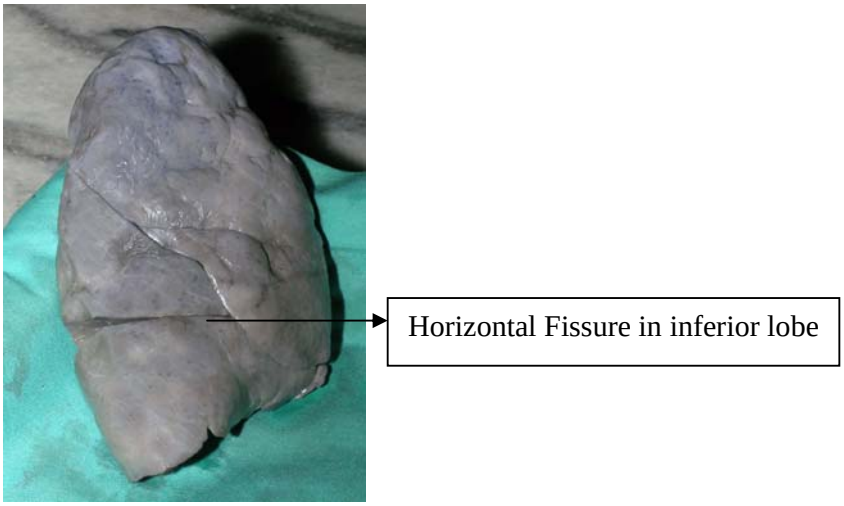


Fig No.23

LEFT PRINCIPAL BRONCHUS WITH ABSENCE OF SECONDARY BRONCHI

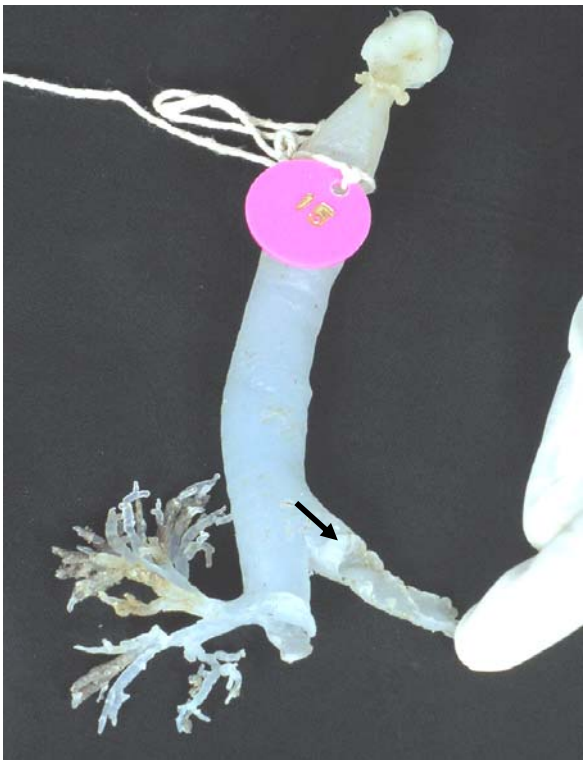


Fig No.32

LEFT PRIMARY BRONCHIAL PATTERN - LINGULAR BRONCHUS ARISING FROM THE INFERIOR LOBAR BRONCHUS

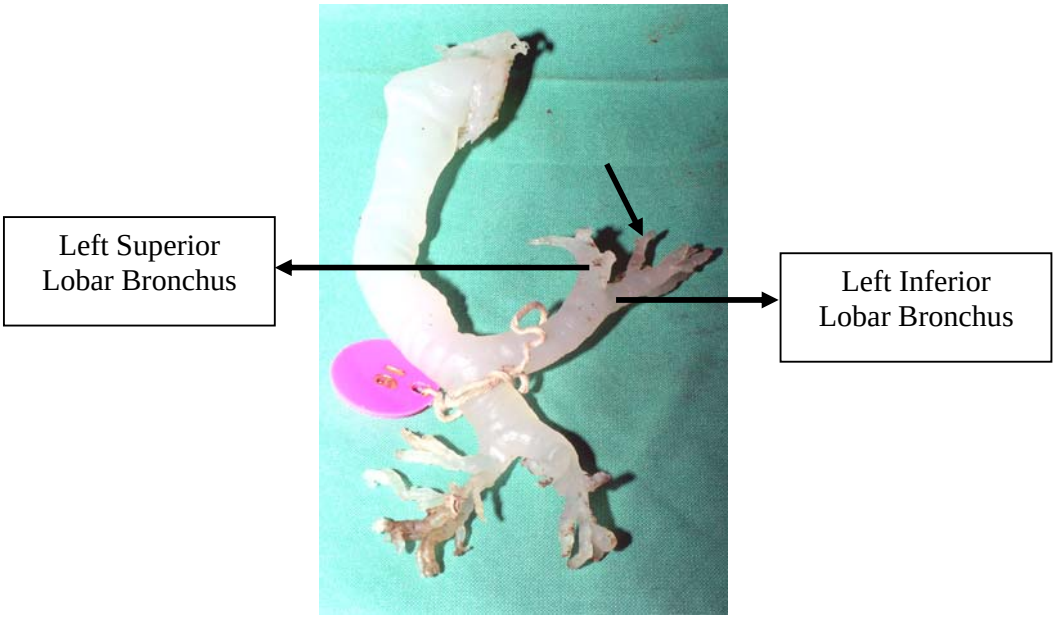


Fig No.33

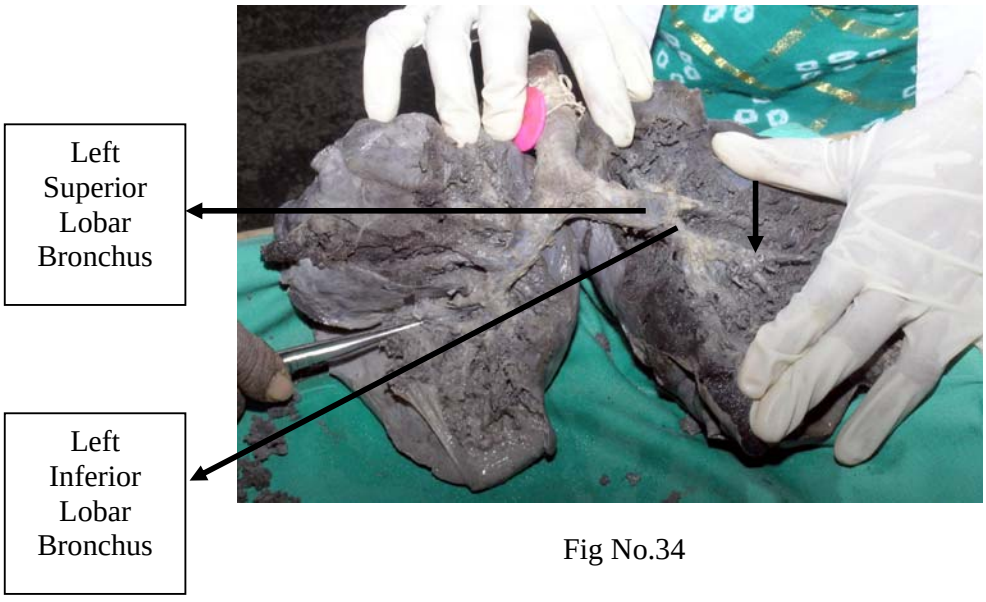


Fig No.34

→ Lingular Bronchus Arising from Inferior Lobar Bronchus

Fig No.30 ADULT AND FOETAL BRONCHOGRAPHS WITH DYE CONTRAST

Fig No.30(i)

Fig No.30(ii)

Adult - Dye Bronchographs

Fig No.30(iii)

Foetal -Dye Bronchograph

INVOLVEMENT OF DISEASES IN LEFT LUNG

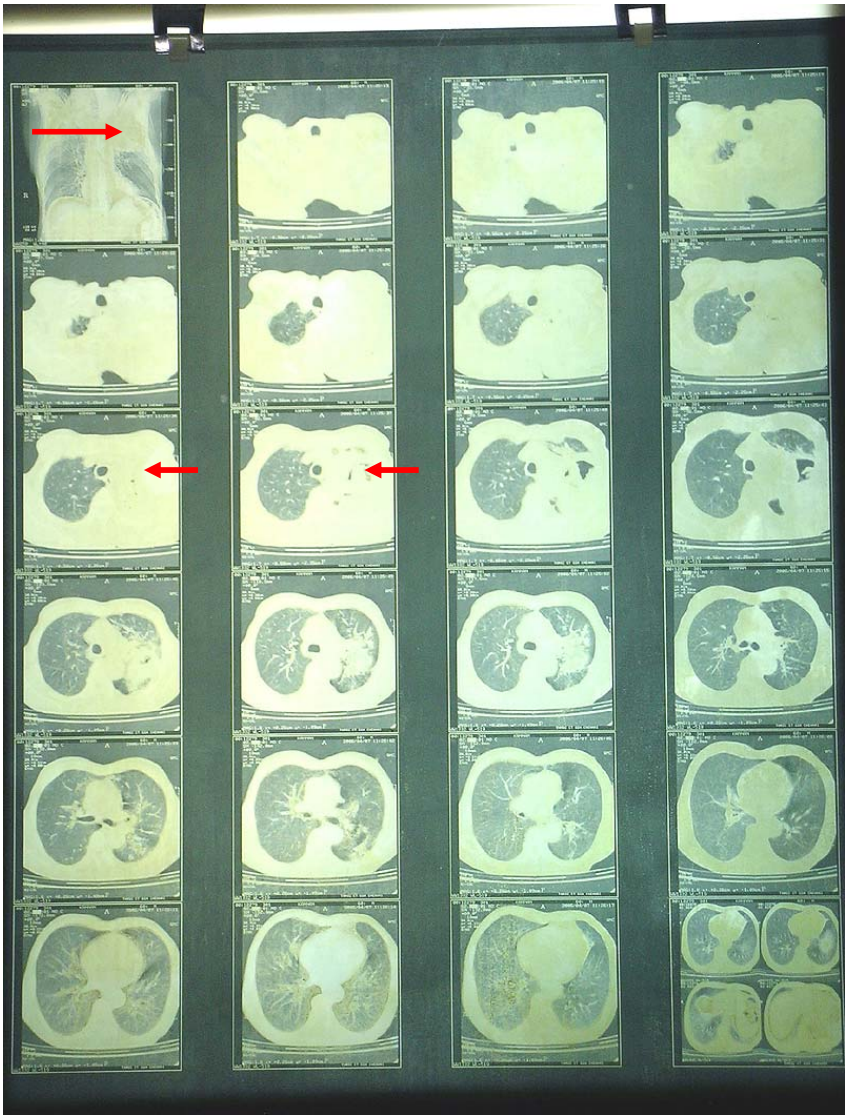


Fig No.56
CT-Scan of Mass Lesion - Left Upper Lobe (S.No.7)

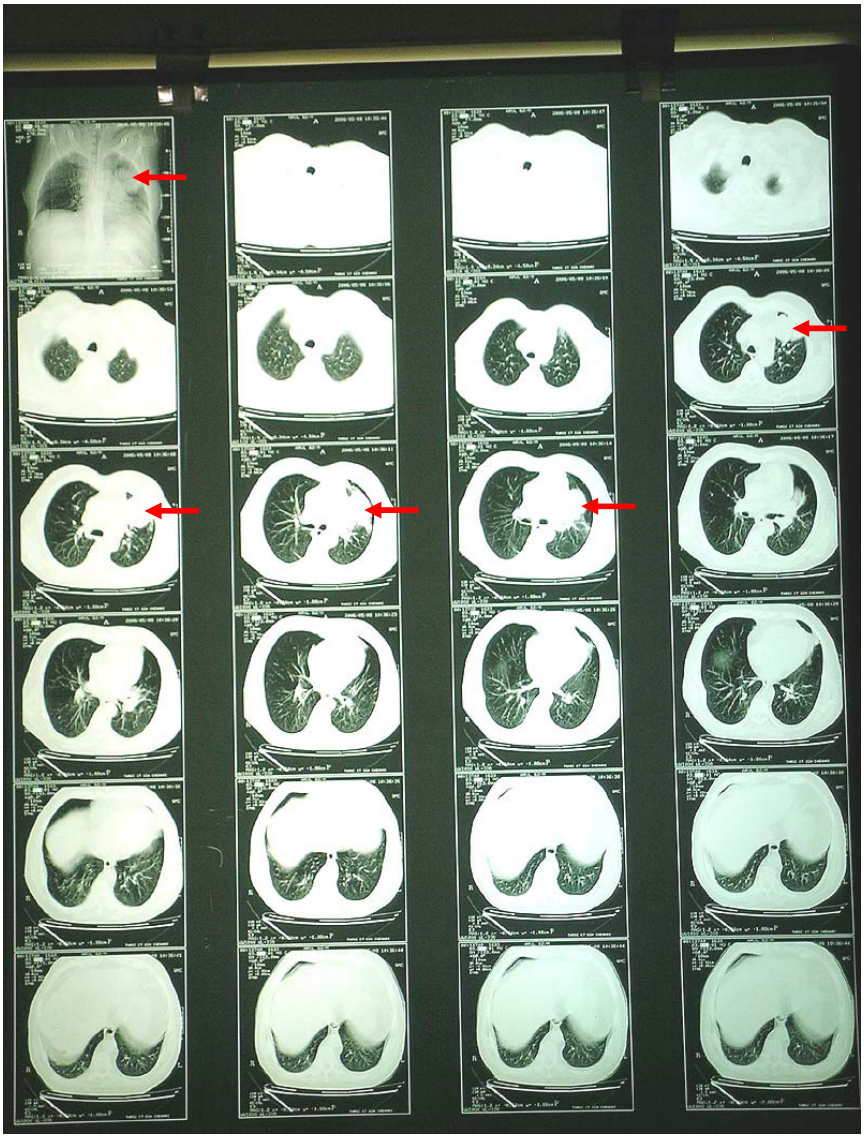


Fig No.57
CT-Scan of Mass Lesion - Left Upper
Lobe and Lingula (S.No.8)

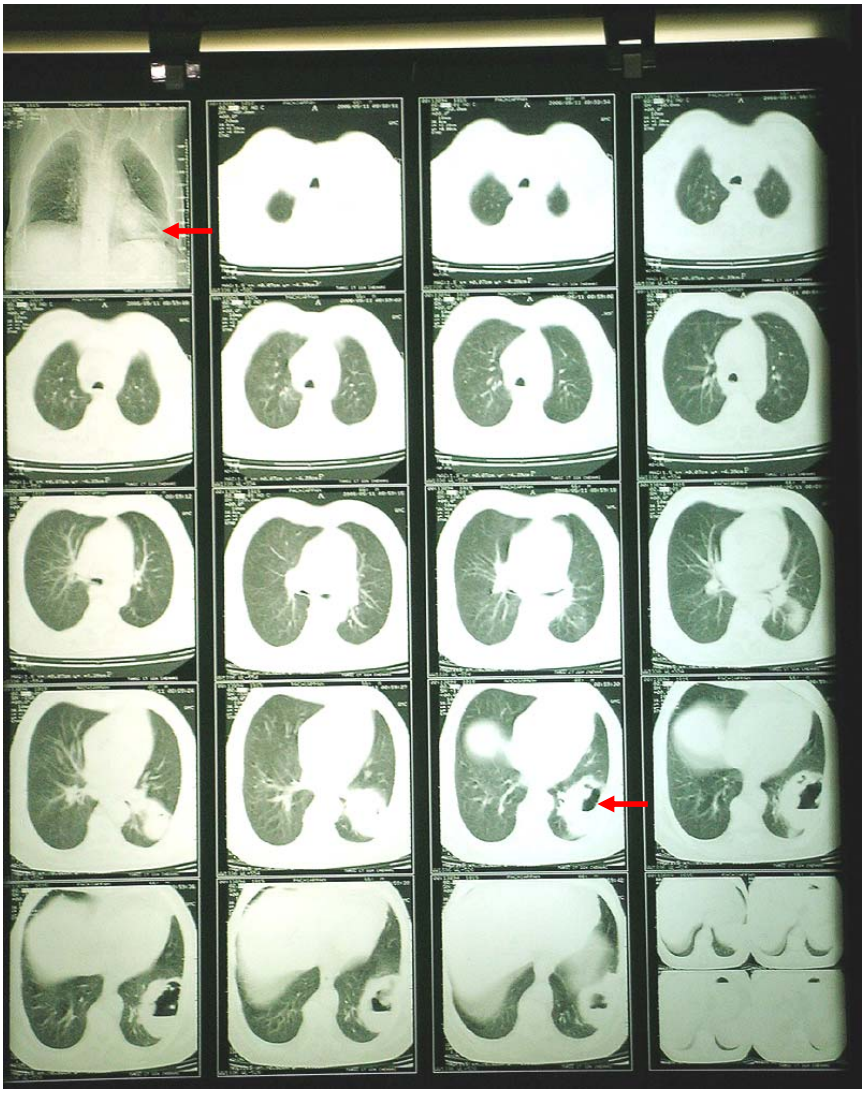


Fig No.58
CT-Scan of Lung Abscess - Left
Lower Lobe (S.No.9)

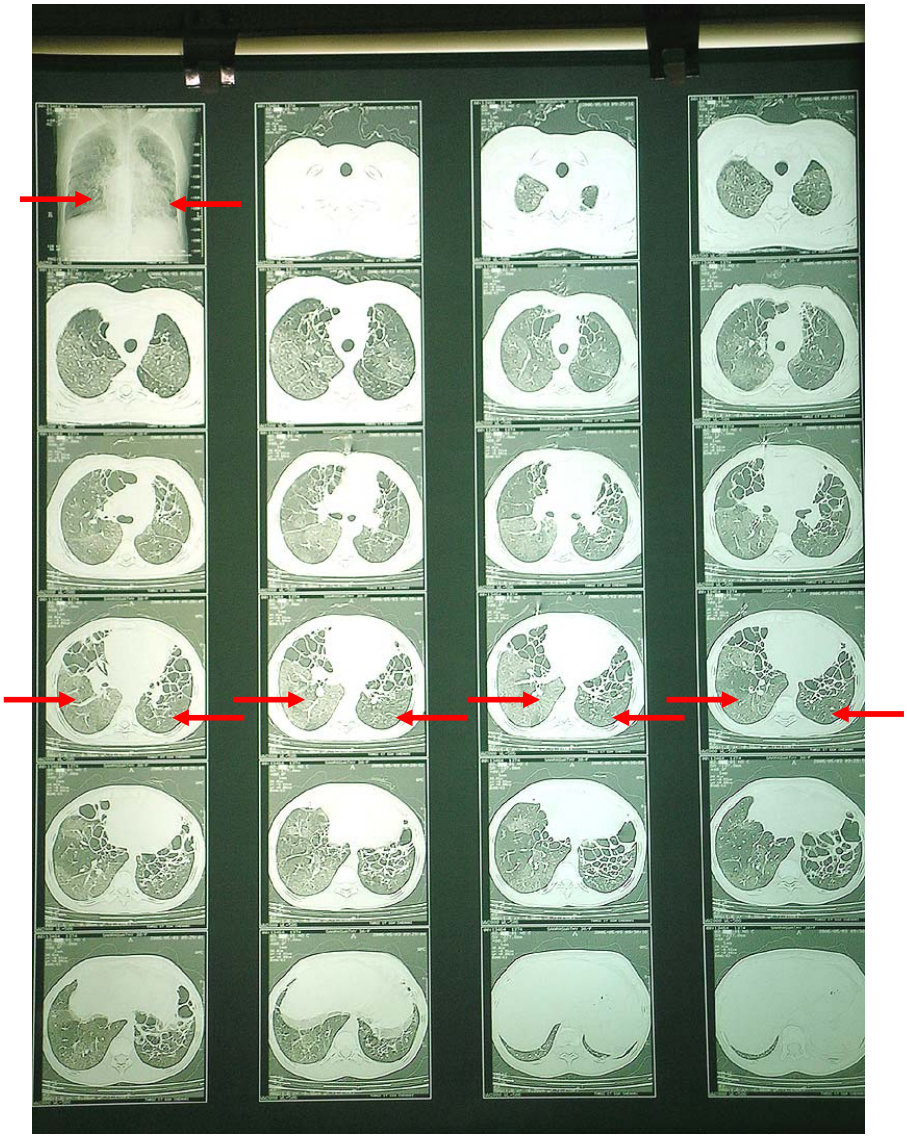


Fig No.59
CT-Scan of Bilateral multiple cystic bronchiectasis - Both (right & left) lower lobes (S.No.10)

INVOLVEMENT OF DISEASES IN RIGHT LUNG

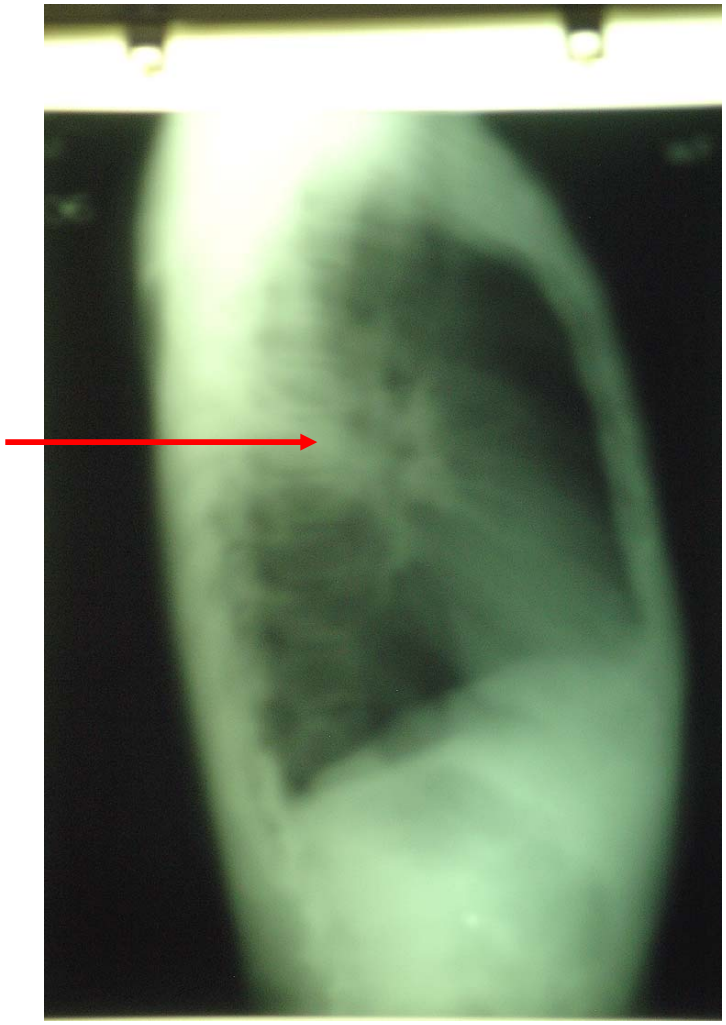


Fig No.52
Lateral View of Chest Radiograph - Distal Obstructive Pneumonitis - Right upper lobe - posterior segment (S.No.1)

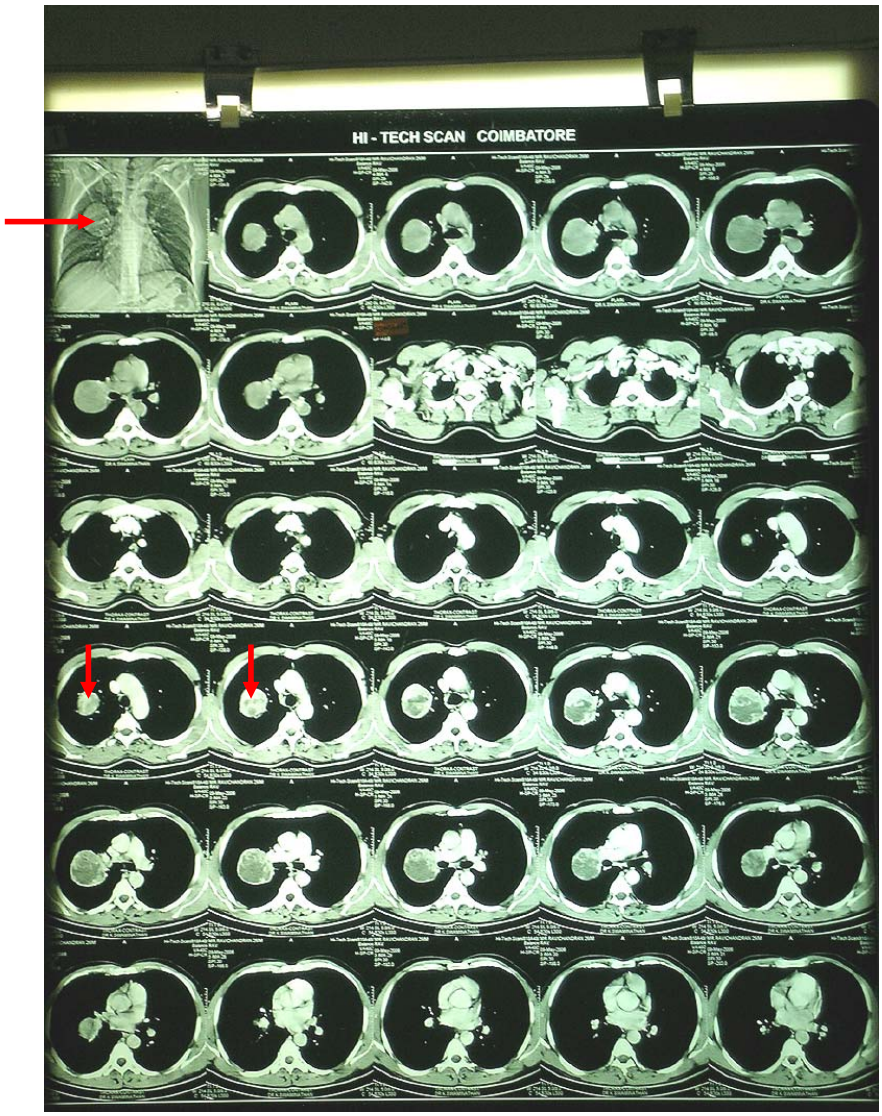


Fig No.53
CT-Scan of Bronchogenic Cyst - Right Upper Lobe (S.No.2)

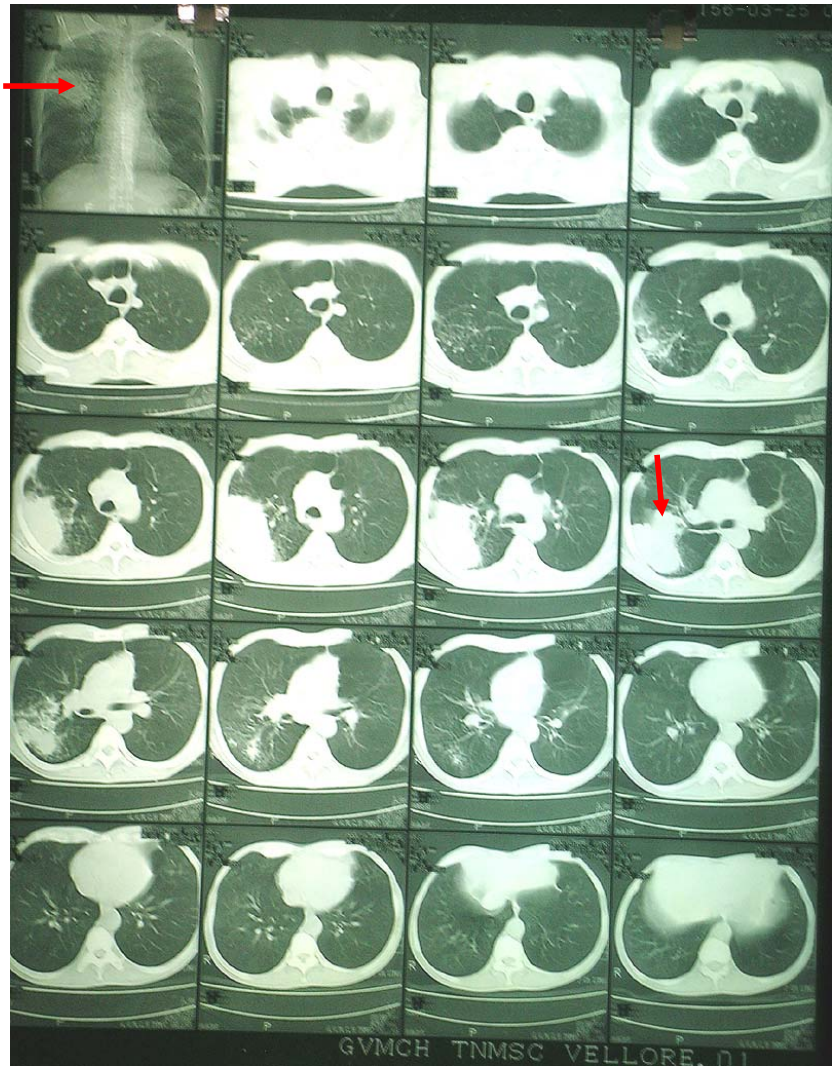


Fig No.54
CT-Scan of Mass Lesion - Right Upper Lobe (S.No.3)

Fig No.55
CT-Scan of Consolidation with acquired bronchictasis - Right Lower Lobe (S.No.5)

Fig No.72 NORMAL ANATOMY OF BRONCHO PULMONARY TREE PATTERN AND BRONCHO PULMONARY SEGEMENTS

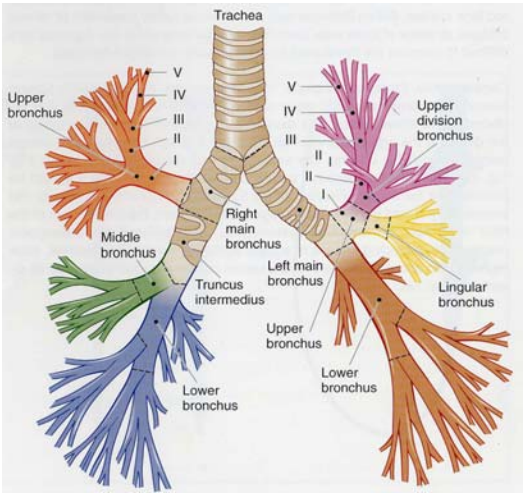


Fig No.72(i)

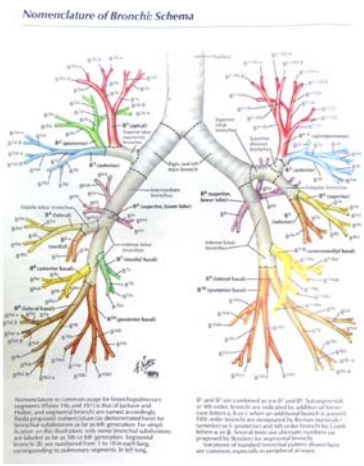


Fig No.72(ii)

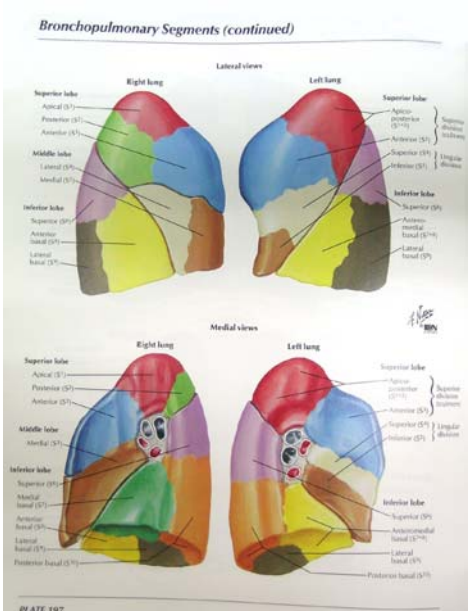


Fig No.72(iii)

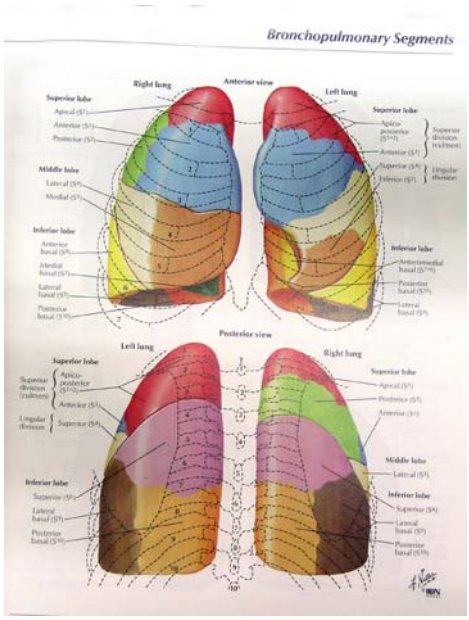
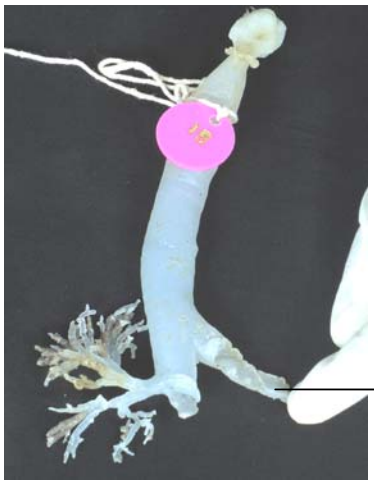


Fig No.72(iv)

LEFT LOWER LOBE SEGMENTAL PATTERN



Left Principal bronchus is single with no divisions

Fig No.49

Absence of medial basal segmental bronchus

Fig No.50

Lateral basal segmental bronchus arising from the inferior lobar bronchus

Fig No.51

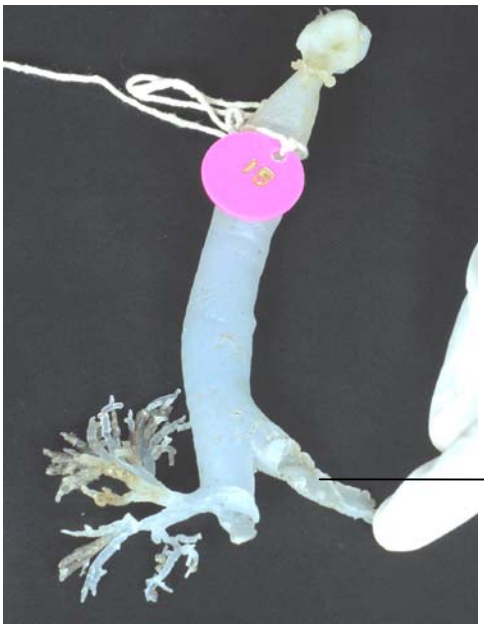
DISSECTED VIEW OF A PAIR OF LUNGS WITH COMMON ORIGIN OF SEGMENTAL BRONCHI

Fig No.48

1. Apicoposterior stem of Right Upper Lobe
2. Apicoposterior stem of Left Upper Lobe
3. Antero - medial stem of Left Lower Lobe
4. Postero- lateral stem of Left Lower Lobe
5. Lymphnode

Common stem for anterior and posterior segmental bronchi

Fig No.46



No Division Of Left Principal Bronchus Into Superior And Inferior Lobar Bronchi

Fig No.47

ABSENCE OF LINGULAR BRONCHUS FROM SUPERIOR LOBAR BRONCHUS

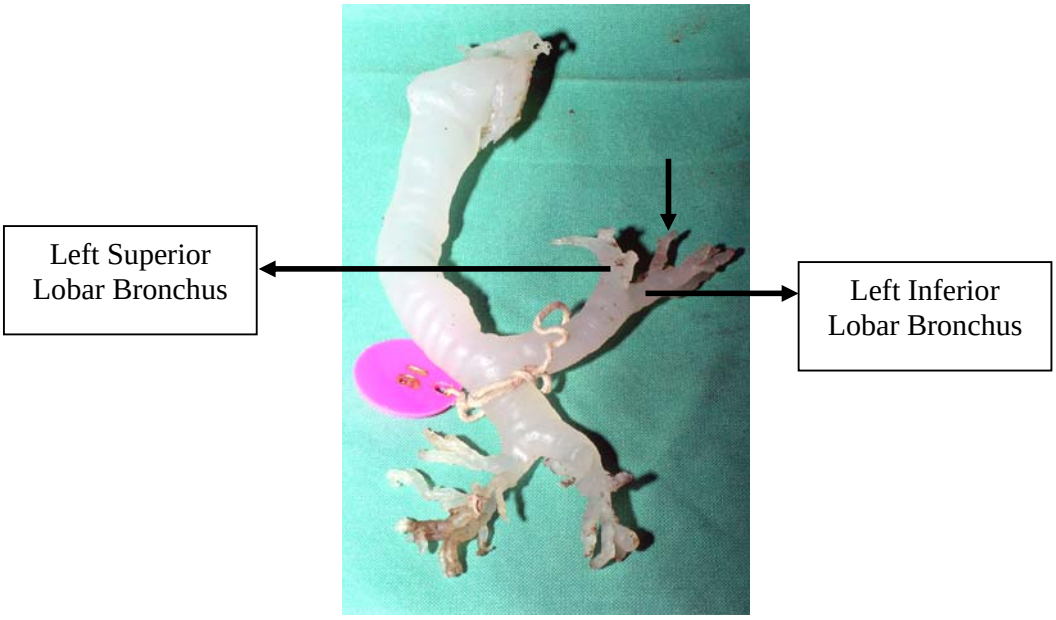


Fig No.44

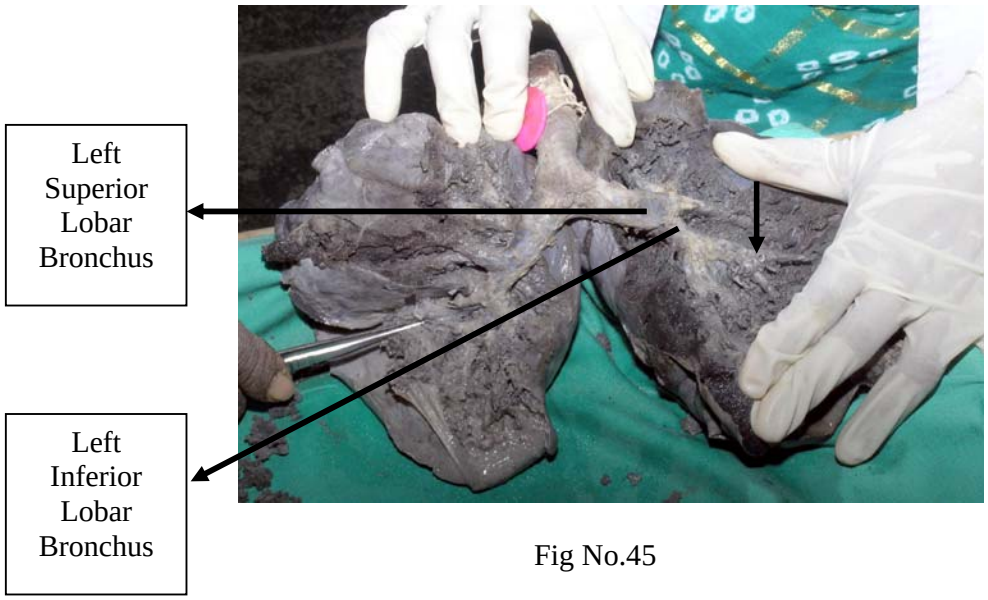


Fig No.45

→ Origin of Lingular Bronchus from Inferior Lobar Bronchus

DISSECTED VIEW OF A PAIR OF LUNGS WITH COMMON ORIGIN OF SEGMENTAL BRONCHI

Fig No.43

1. Apicoposterior stem of Right Upper Lobe
2. Apicoposterior stem of Left Upper Lobe
3. Antero - medial stem of Left Lower Lobe
4. Postero- lateral stem of Left Lower Lobe
5. Lymphnode

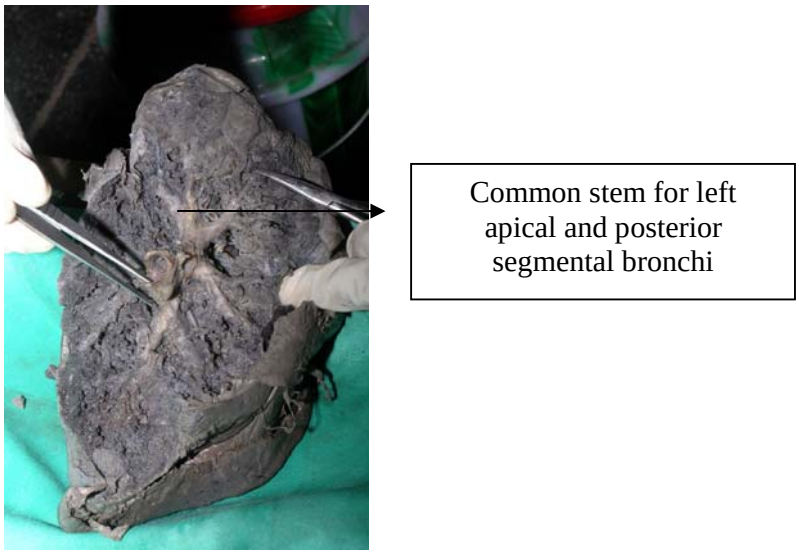
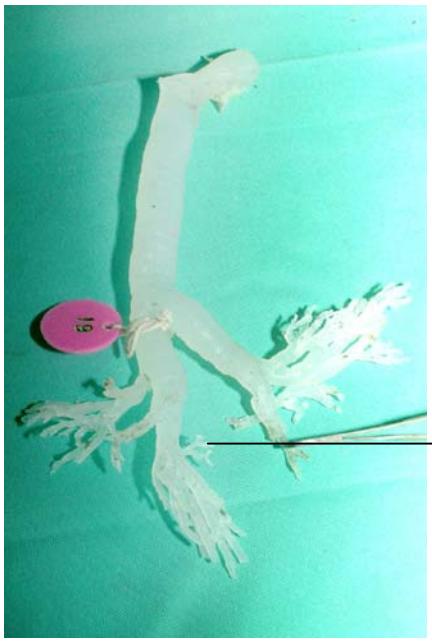
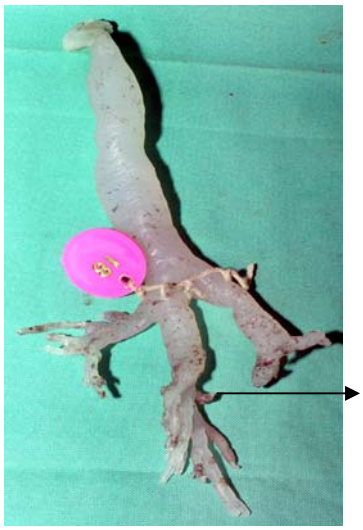


Fig No.43a



Sub superior segmental bronchus

Fig No.41



Sub superior segmental bronchus

Fig No.42

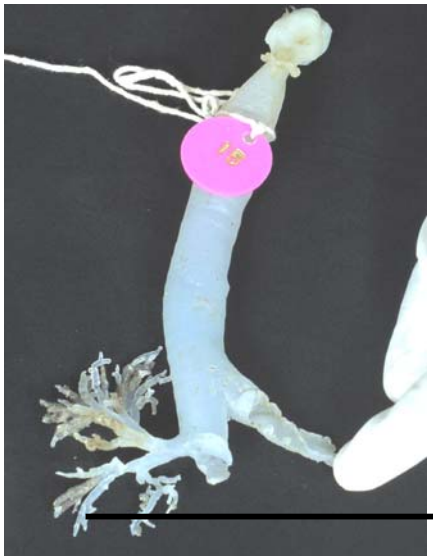
Fig No.39

Fig No.40

RIGHT MIDDLE LOBAR BRONCHIAL PATTERN

Accessory Segmental bronchus from the middle lobar bronchus

Fig No.36



Accessory Segmental bronchus from the middle lobar bronchus supplying the superior segment of the inferior lobe

Fig No.37

TRIFURCATION - RIGHT UPPER LOBE

Fig No.35v_1

→ Common Origin of Apical Posterior and Anterior Segments of Right Upper Lobe.

Fig No.31 ORIGIN OF RIGHT MIDDLE LOBAR BRONCHUS AND THE COURSE OF INTERMEDIATE BRONCHUS

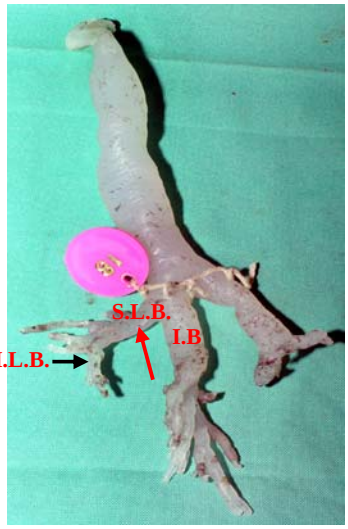


Fig No.31(i)

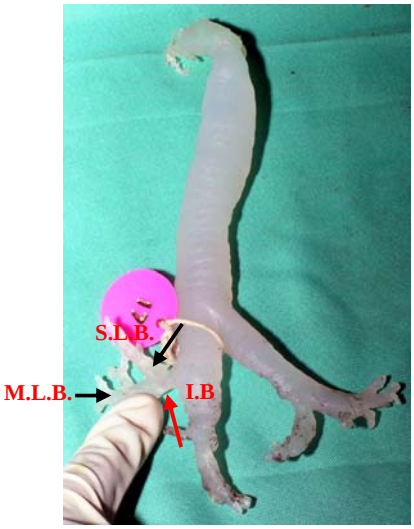


Fig No.31(ii)

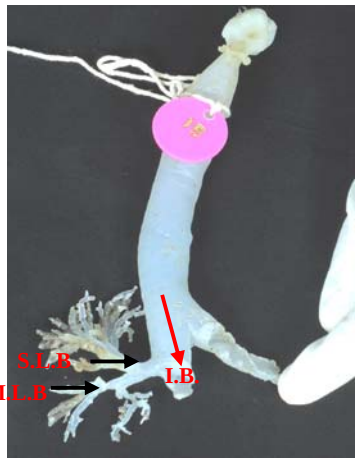


Fig No.31(iii)

One specimen with Rudimentary bronchus intermedius

→ denotes in :
Fig.No.31(i) & 31(ii) Middle lobar bronchus arises from the superior lobar bronchus and the intermediate bronchus continues as the inferior lobar bronchus
Fig.No.31(iii) Middle lobar and inferior lobar bronchi arise in a common stem from the superior lobar bronchus and bronchus intermedius is rudimentary

SLB - Right Superior Lobar Bronchus
MLB - Right Middle Lobar Bronchus
I.B - Intermediate Bronchus

LEFT LUNG WITH OBLIQUE AND HORIZONTAL FISSURES

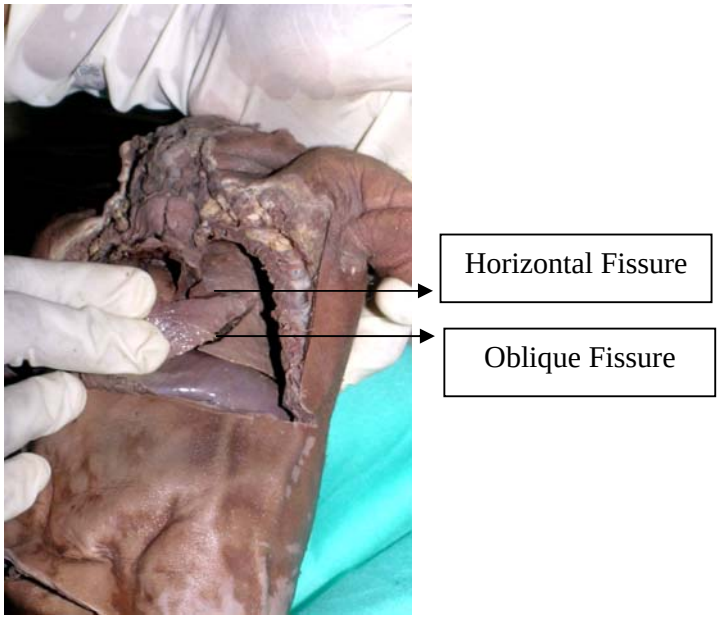


Fig No.24

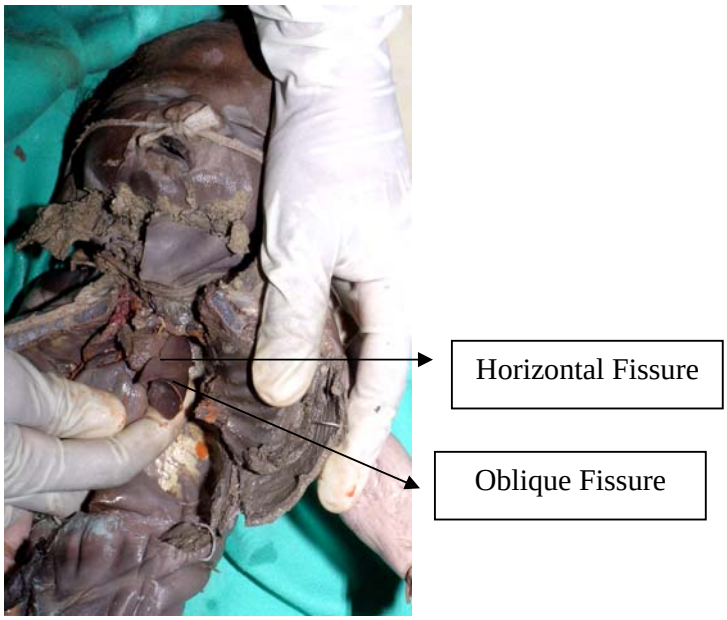


Fig No.25

Fig No. 19 MEDIAL VIEWS OF RIGHT AND LEFT LUNGS

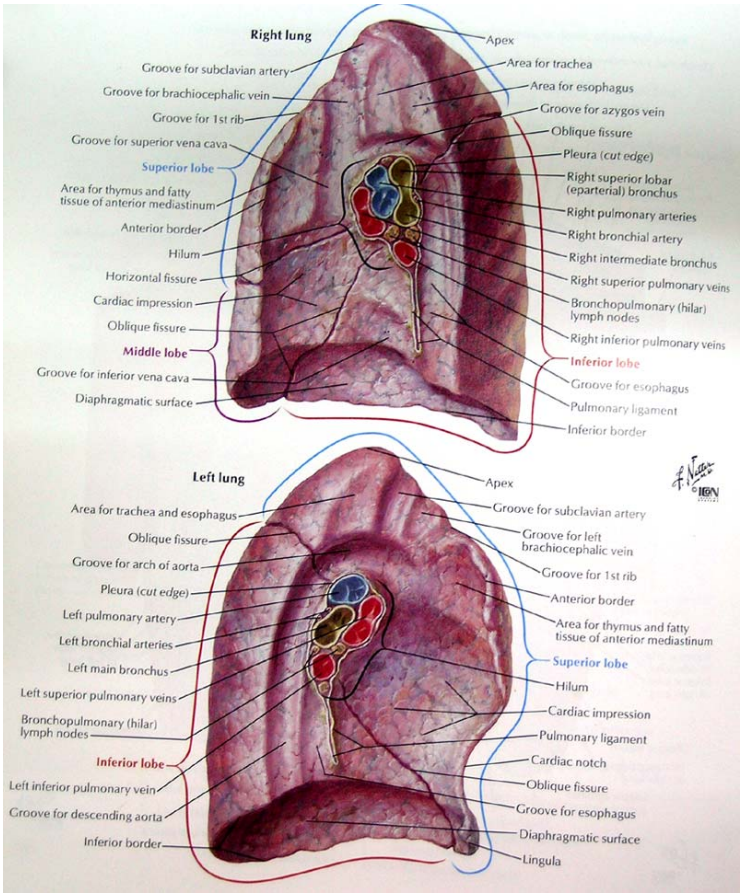
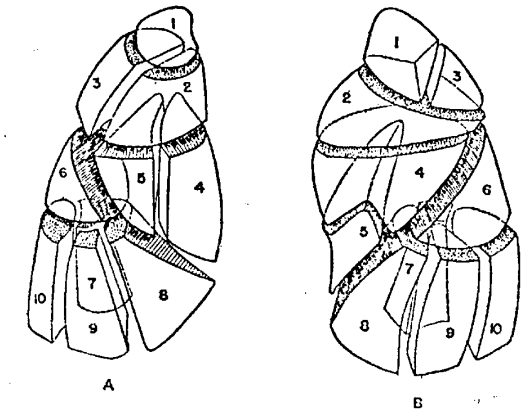


Fig No.10 BRONCHO PULMONARY SEGMENTS



A - Segments of right lung
Upper lobe:
1. Epical, 2. Anterior, 3. Posterior
Middle lobe:
4. Medial, 5. Lateral,
Lower lobe:
6. Superior, 7. Medial basal, 8. Anterior basal
9. Lateral basal, 10. Posterior basal

B - Segments of left lung
Upper lobe:
1. Epical, 2. Anterior, 3. Posterior,
4. Superior lingular, 5.Inferior lingular
Lower lobe:
6. Superior, 7. Medial basal, 8. Anterior basal
9. Lateral basal, 10. Posterior basal

Fig No.11 THE LOBE OF THE AZYGOS VEIN

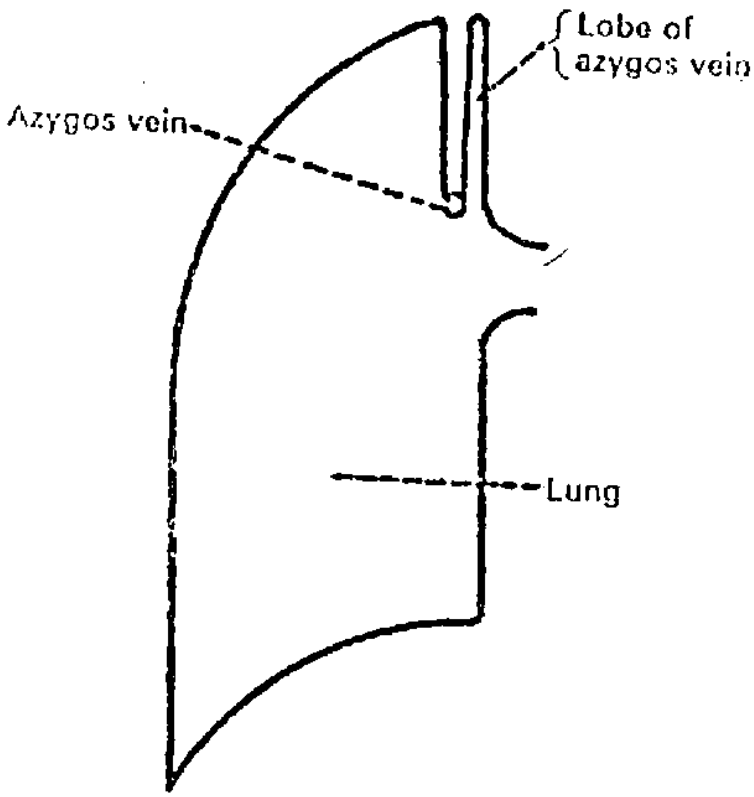


Fig No.11a VARIOUS FROMS WHCIH LOBE OF AZYGOS VEIN ASSUME. MEDIASTINAL SURFACE OF LUNG IS DEPICTED

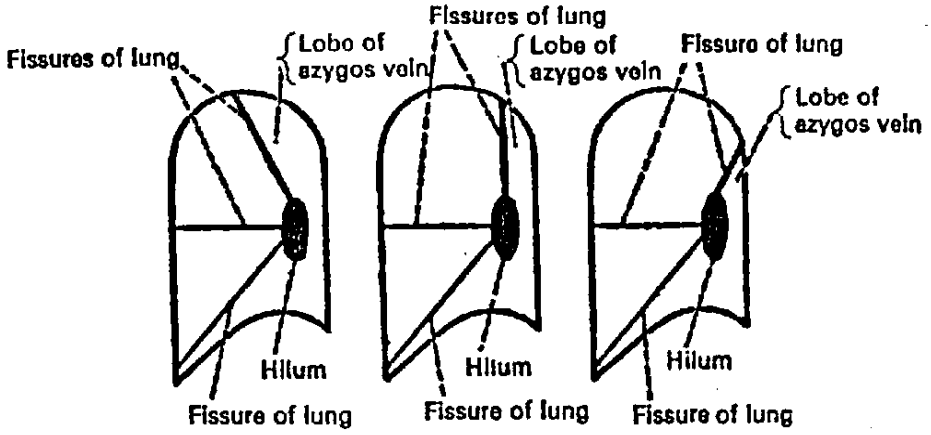
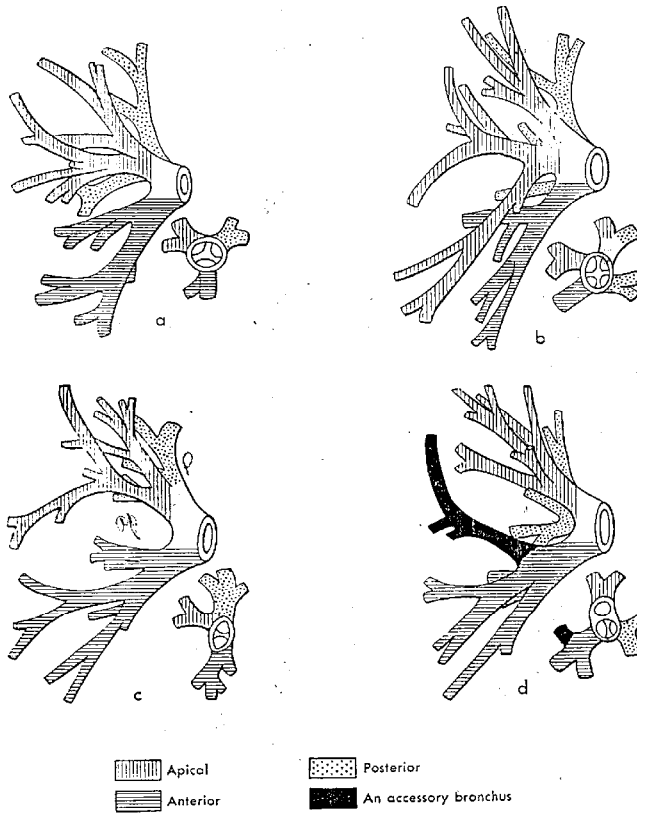
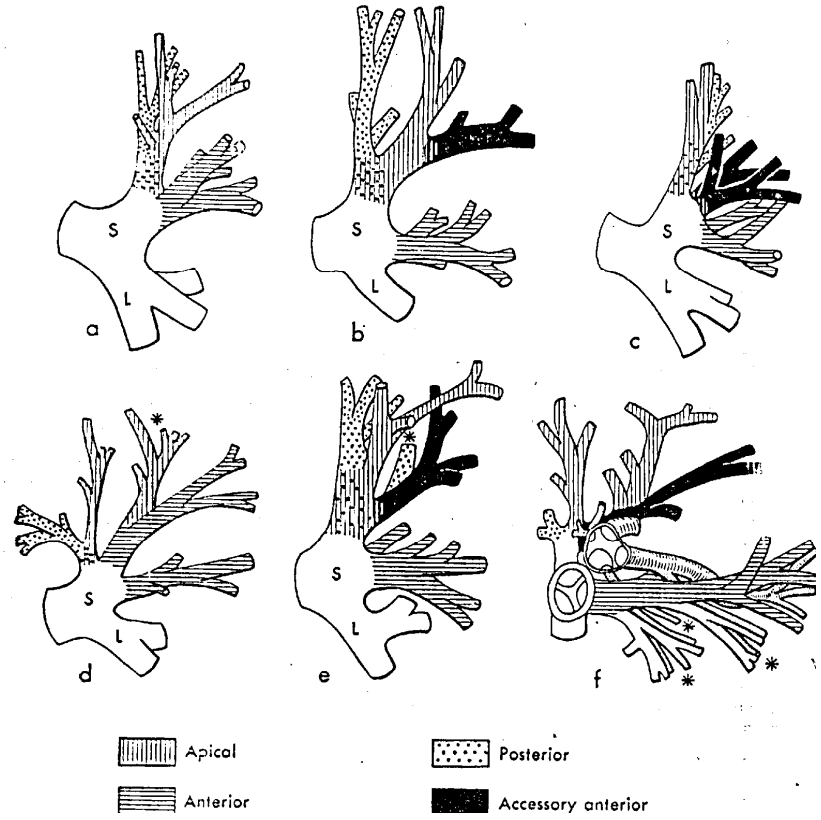


Fig No. 8 VARIOUS PATTERNS OF ORIGIN AND BRANCHING OF THE SEGMENTAL BRONCHI OF RIGHT UPPER LOBE



A. Shows the more commonly prevailing pattern of a trifurcation of superior bronchus into 3 segmental bronchi

Fig No.9 VARIATIONS IN THE UPPER DIVISION(S) BRONCHI OF THE LEFT UPPER LOBE SEEN FROM THE MEDIASTINAL ASPECT



A. Prevailing pattern (74%)

B, C & D. Splitting of the anterior bronchus (33%) and in 27% trifurcation

D. Several types of displacement of bronchus (asterisk) of the epical segment

E. Displacement of a bronchus (asterisk) of the posterior segments

F. Distortion of the bronchial pattern brought about by the presence of the left pulmonary artery

Fig No. 6 VENTRAL VIEWS OF DEVELOPMENT OF MAJOR BRONCHI OF HUMAN LUNGS

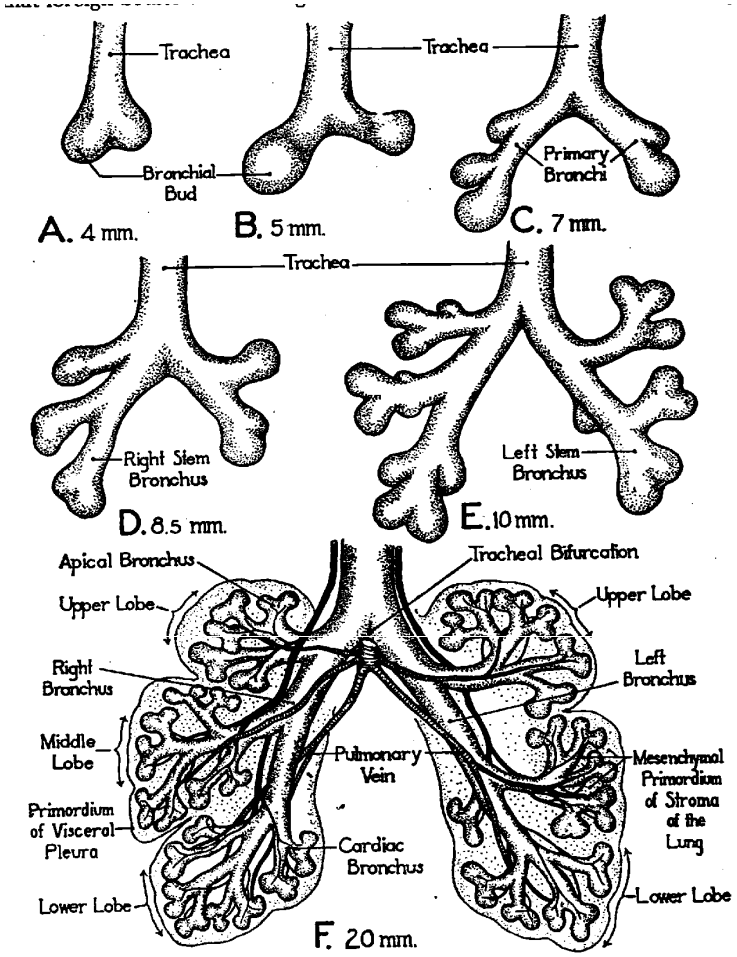


Fig No. 7 VENTRAL VIEW OF DEVELOPMENTAL PLAN OF HUMAN LUNGS

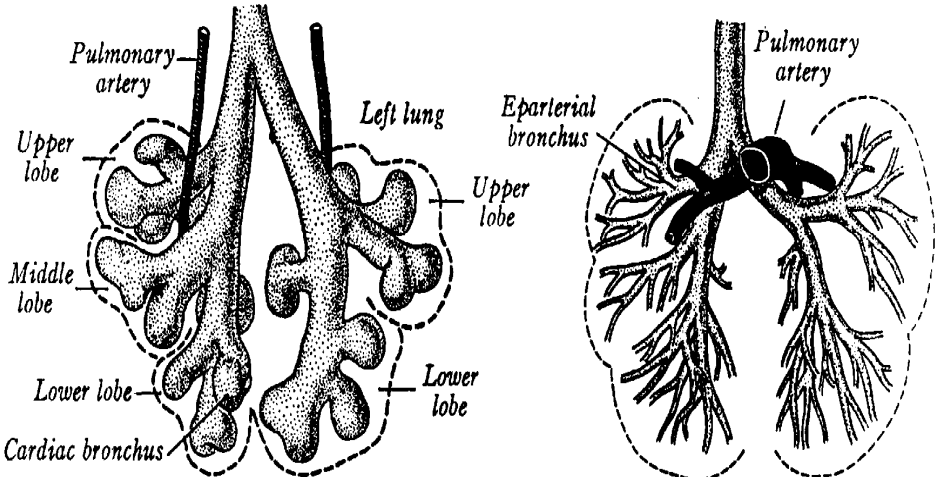


Fig No.12 ACCESSORY LOBES OF THE LUNGS

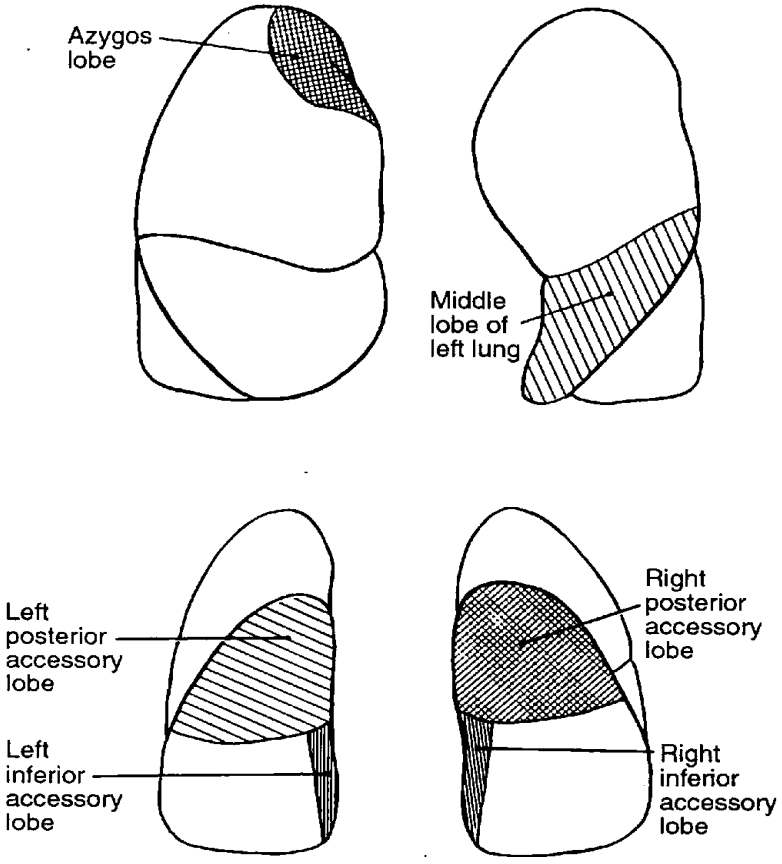
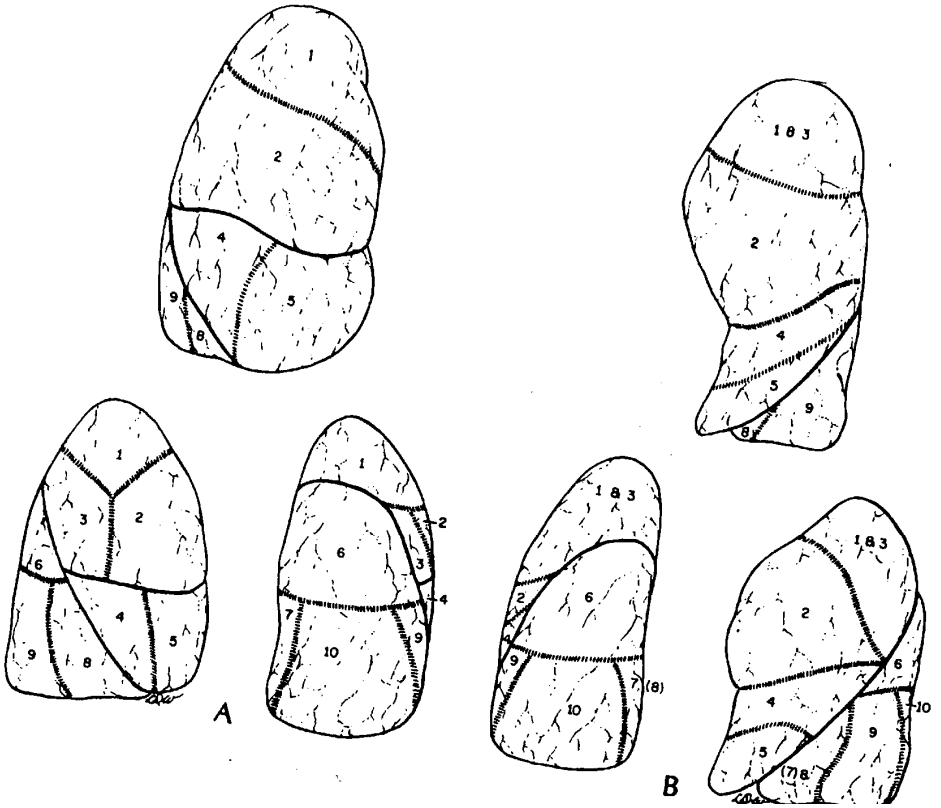


Fig No.13 TOPOGRAPHIC POSITIONS OF THE BRONCHO PULMONARY SEGMENTS IN ANTERIOR, LATERAL AND POSTERIOR VIEWS



Right Lung

Left Lung

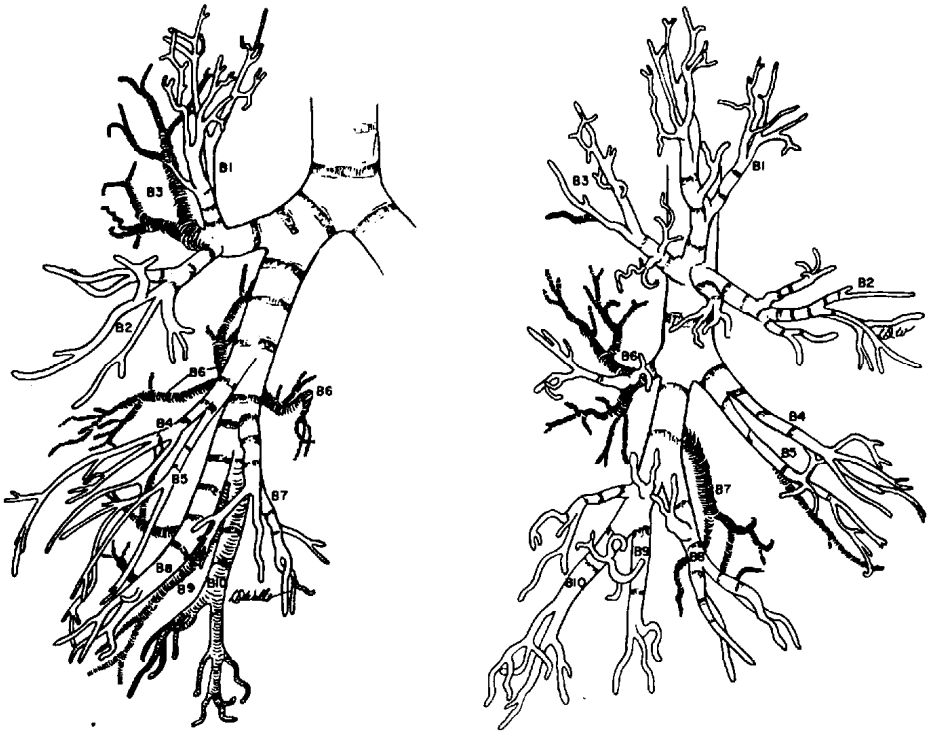
A - Segments of Right Lung

1. Apical 2. Anterior 3. Posterior
4. Lateral 5. Medial
6. Superior (Apical Basal)
7. Medial Basal
8. Anterior Basal
9. Lateral Basal
10. Posterior Basal

B - Segments of Left Lung

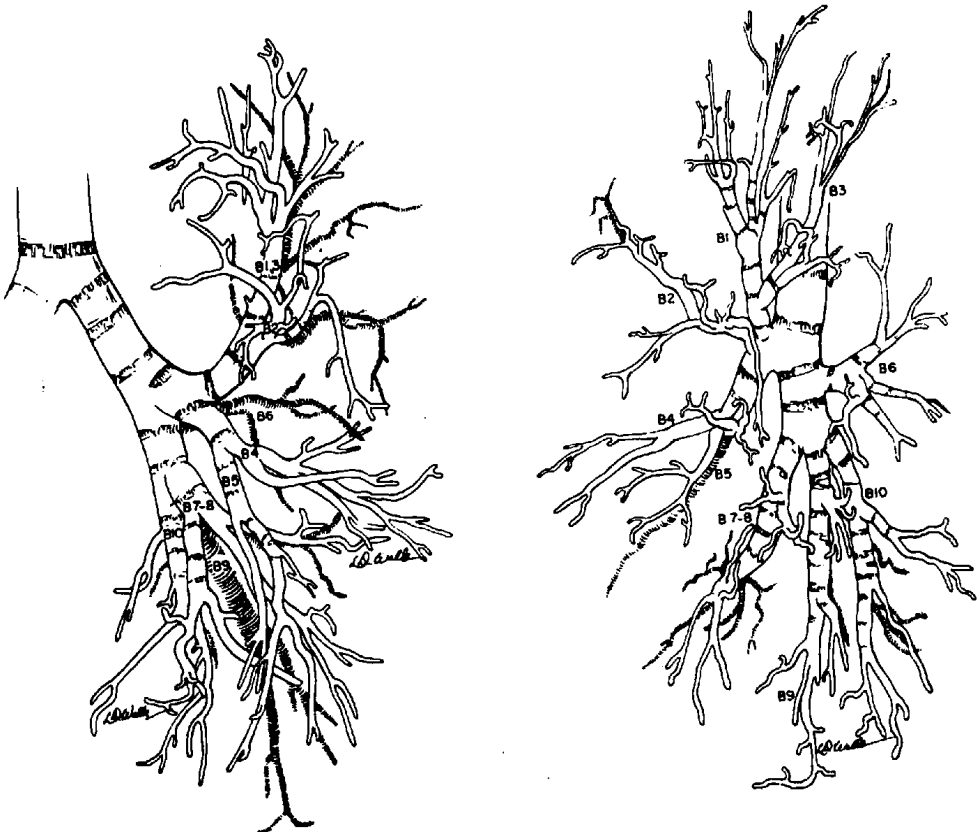
1,3-Apical, Posterior 2. Anterior
4. Superior Lingular
5. Inferior Lingular
6. Superior (Apical Basal)
7. Medial Basal
8. Anterior Basal
9. Lateral Basal
10. Posterior Basal

Fig No.13a RIGHT BRONCHIAL TREE- ANTERIOR AND LATERIAL VIEWS



B1 - Apical
B2 - Anterior
B3 - Posterior
B4 - Lateral
B5 - Medial
B6 - Superior (Apical Basal)
B7 - Medial Basal
B8 - Anterior Basal
B9 - Lateral Basal
B10 - Posterior Basal

Fig No.13b LEFT BRONCHIAL TREE-ANTERIOR AND LATERAL VIEWS

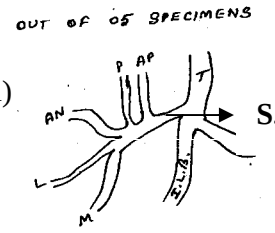


B1,3 - Apical, Posterior
B2 - Anterior
B4 - Superior Lingular
B5 - Inferior Lingular

B6 - Superior (Apical Basal)
B7,8 - Medial & Anterior Basal (Antero - Medial)
B9 - Lateral Basal
B10 - Posterior Basal

Fig No.35 RIGHT SUPERIOR LOBAR BRONCHIAL PATTERN

Fig No.35(i)



S.L.B

Fig No.35(ii)

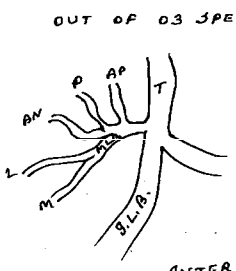


Fig No.35(iii)

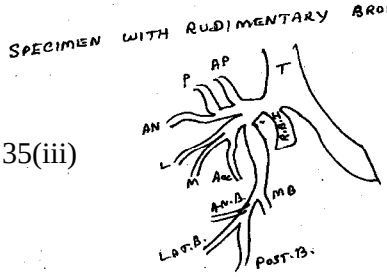


Fig No.35(iv)

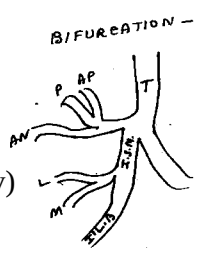
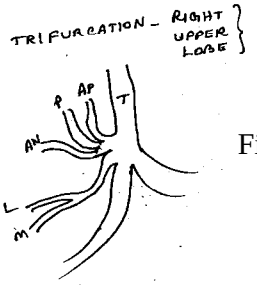
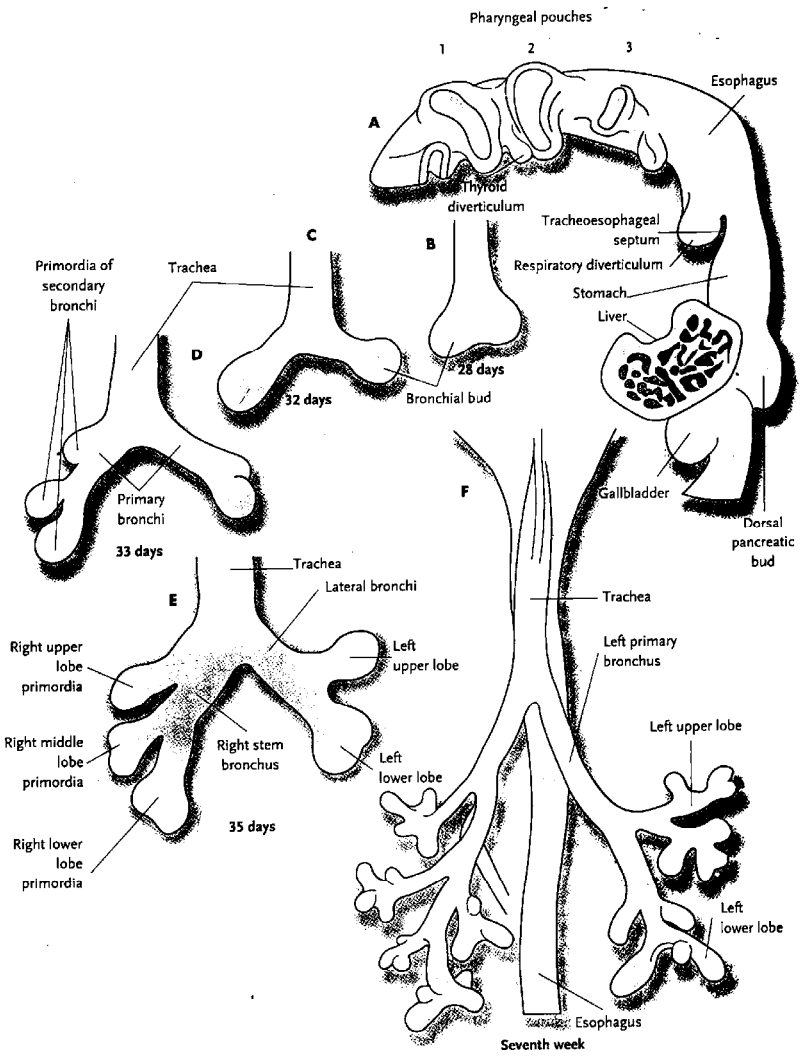


Fig No.35(v)



T - Trachea
Ap - Apical
Post - Posterior
An - Anterior
La - Lateral
Med - Medial
AB - Apical Basal
MB - Medial Basal
Ant. B- Anterior Basal
Lat. B - Lateral Basal
PB - Posterior Basal
S.L.B. - Superior Lobar Bronchus
M.L.B. - Middle Lobar Bronchus
I.L.B - Interior Lobar Bronchus
R.B. - Rudimentary Bronchus

Fig No.5 DEVELOPMENT OF THE MAJOR BRANCING PATTERNS OF THE LUNGS



A - Lateral view of the pharynx showing the respiratory diverticulum in a 4-week-old embryo

B - At 4 week

C - At 32 days

D - At 33 days

E - At the end of the 5th week

F - Early in the seventh week

TABLE No. 1

Right lung	Left lung
Upper lobe	**Upper lobe Superior division**
Apical 1 [1]	Apical posterior 1 + 3 [1 + 2]
Anterior 2 [3]	Anterior 2 [3]
Posterior 3 [2]	**Inferior division - lingula**
	Superior lingular 4
	Inferior lingular 5
Middle lobe	**Middle lobe**
Lateral 4 [4]	-
Medial 5 [5]	-
Lower lobe	**Lower lobe**
Superior 6 [6]	Superior 6 [6]
Medial basal [cardiac] 7 [7]	Antero medial 7 + 8
	[medial basal cardiac] [7]
Anterior basal 8 [8]	[Anterior basal] [8]
Lateral basal 9 [9]	Lateral basal 9 [9]
Posterior basal 10 [10]	Posterior basal 10 [10]

TABLE - No.2

BROCK AND JACKSON & HUBER name the broncho pulmonary segments as in the following tabular column:

International nomenclature	Brock	Jackson & Huber
Right upper lobe bronchus		
Apical (1)	Pectoral	Anterior
Posterior (2)	Sub apical	Posterior
Anterior (3)	Apical	Apical
Middle lobe bronchus		
Lateral (4)	Lateral	Lateral
Medial (5)	Medial	Medial
Right lower lobe bronchus		
Apical (6)	Apical	Superior
Medial basal(cardiac)(7)	Cardiac	Medial basal(cardiac)
Anterior basal(8)	Anterior basal	Anterior basal
Lateral basal(9)	Lateral basal	Lateral basal
Posterior basal(10)	Posterior basal	Posterior basal
Left upper lobe bronchus		
Upper division		Upper division
Apical(1)	Apico pectoral	Apical
Apico posterior(1 & 2)	apical	Apico posterior
Posterior(2)	-	Posterior
Anterior(3)	sub apical	Anterior
Lingula	pectoral	Lower(lingular)division
Superior(4)	Lingula	Superior
Inferior(5)	Upper	Inferior
Left lower lobe bronchus	lower	
Apical(6)	Apical	Superior
Anterior basal(8)	Anterior basal	Anterior medial basal
Lateral basal(9)	Middle basal	Lateral basal
Posterior basal(10)	Posterior basal	Posterior basal

Two of the five systems, those of Brock and of Jackson & Huber, are included. The problem of the presence of a medial basal segment on the left was not resolved and was omitted entirely. Brock’s apical instead of Jackson & Huber’s superior was adopted for the first branch of the lower lobe.

TABLE - No.3

NATURE OF FISSURES IN RIGHT LUNG

S.No.	Nature of the Fissure	No.of Specimen	Percentage
1	One oblique fissure	32	100
2.	Complete horizontal fissure	29	90.6
3.	Incomplete horizontal fissure	03	09.4
4.	Accessory horizontal fissure	02	06.3

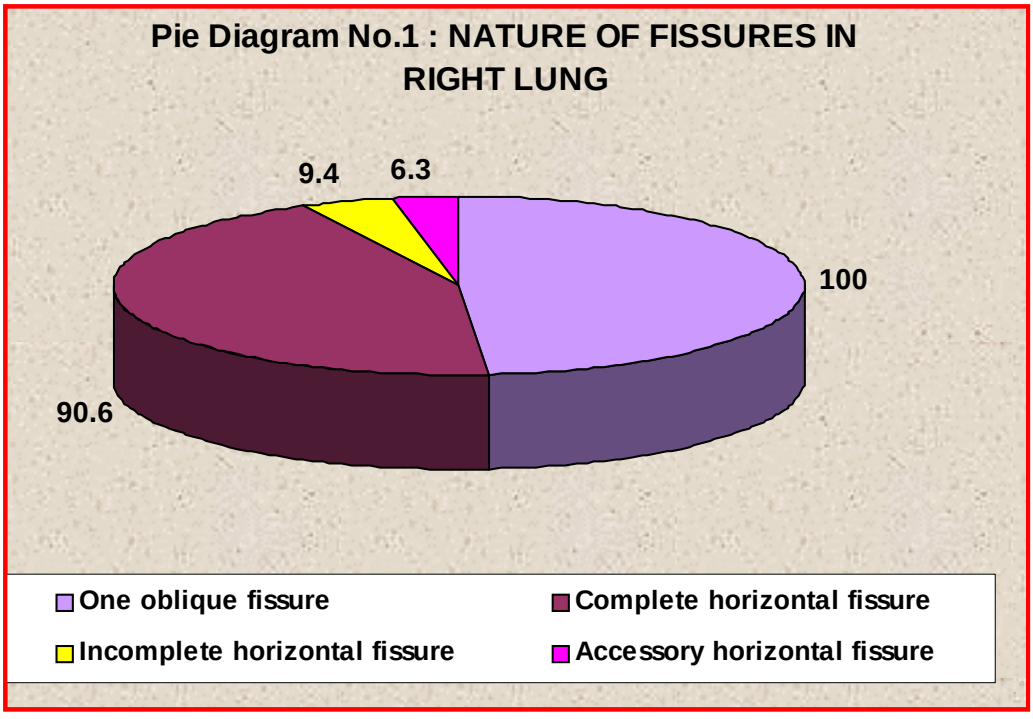


TABLE - No.4

NUMBER OF FISSURES IN LEFT LUNG

S.No.	Nature of the Fissure	Number	Percentage
1	Oblique and Horizontal fissures	02	6.3

TABLE No.5

PRESENCE OF AZYGOS LOBE

S.No.	Side of the Organ	No.of Cases	Percentage
1	Right lung	03	9.4
2.	Left lung	02	6.3

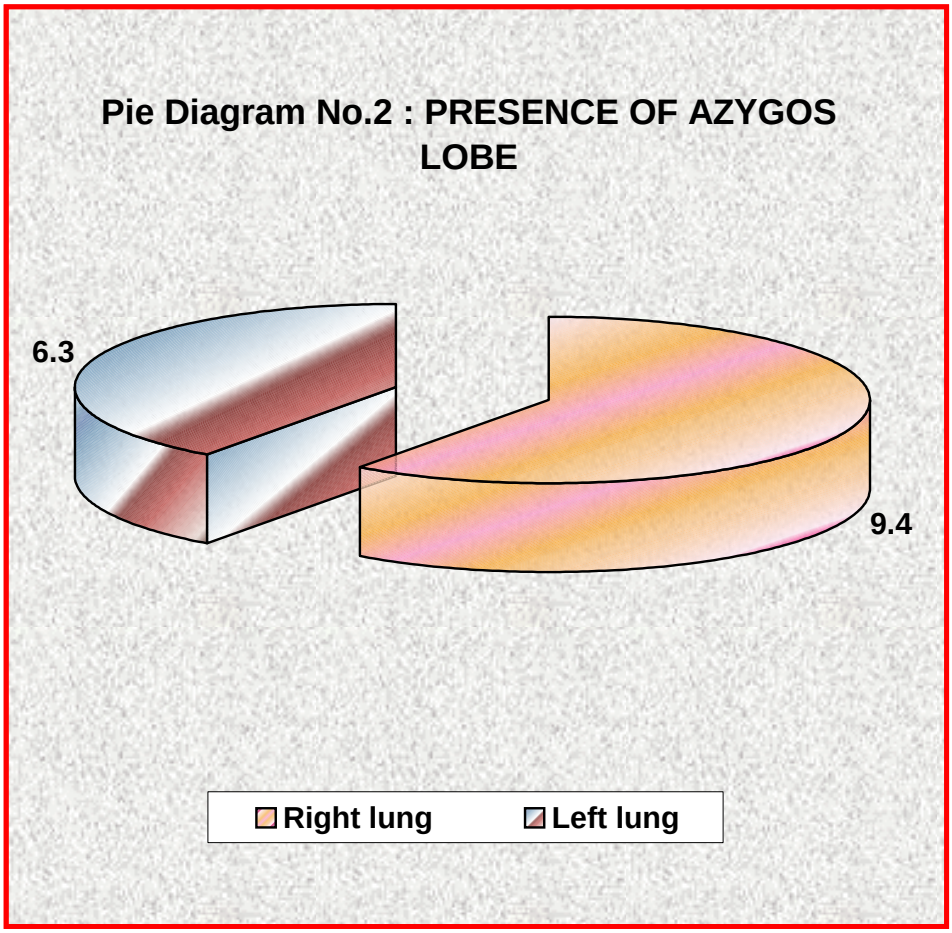


TABLE No.6

PATTERN OF RIGHT PRIMARY BRONCHUS

S. No.	Origin of middle lobar bronchus and the course of the intermediate bronchus	No.of Specimen	Percentage
1	Middle lobar bronchus arising from the intermediate bronchus and the intermediate bronchus continuing as the inferior lobar bronchus	23	71.9
2.	Middle lobar bronchus arising from the superior lobar bronchus and the intermediate bronchus continues as the inferior lobar bronchus	08	25.0
3.	Middle lobar and inferior lobar bronchi arising from the superior lobar bronchus and the intermediate bronchus is rudimentary	01	03.1

TABLE No.7

RIGHT SUPERIOR LOBAR BRONCHIAL PATTERN

S. No.	Pattern of the segmental bronchi	No.of Specimen	Percentage
1.	Normal pattern	21	65.6
2.	Continuation of superior lobar bronchus as a middle lobar bronchus after apical, posterior and anterior segmental bronchi	05	15.7
3.	Apical, posterior & anterior segmental bronchi from superior lobar bronchus, lateral and medial segmental bronchi from middle lobar bronchus but the middle lobar bronchus is from superior lobar bronchus.	03	09.4
4.	Apical basal segmental bronchus from middle lobar bronchus and all other basal segmental bronchi from the inferior lobar bronchus.	01	3.1
05.	Apico-posterior and anterior segmental bronchi	01	3.1
05.	Trifurcation with short superior lobar bronchus	01	3.1

TABLE - No. 8

RIGHT MIDDLE LOBAR BRONCHIAL PATTERN

Segmental Variation	Number	Percentage
Normal pattern of lateral and medial segmental bronchi	30	93.7
Accessory segmental bronchus from the middle lobar bronchus	02	06.3

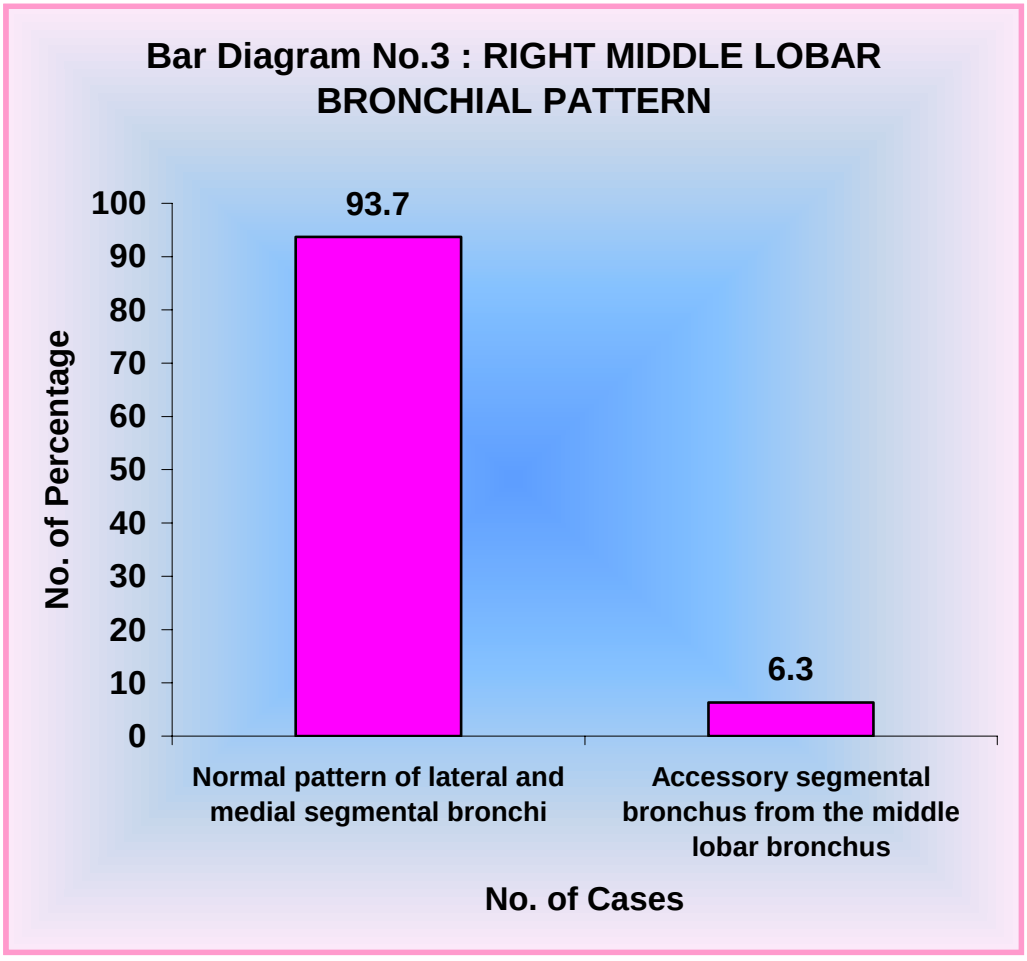


TABLE No - 9

RIGHT INFERIOR LOBAR BRONCHIAL PATTERN

Sl. No.	Segmental Variation	No.of Specimens	Percentage
01.	All the five basal segmental bronchi arising separately	30	93.8
02.	Medial basal segmental bronchus arising from the posterior basal segments	01	03.1
03.	Common origin of anterior and medial basal segments	01	03.1

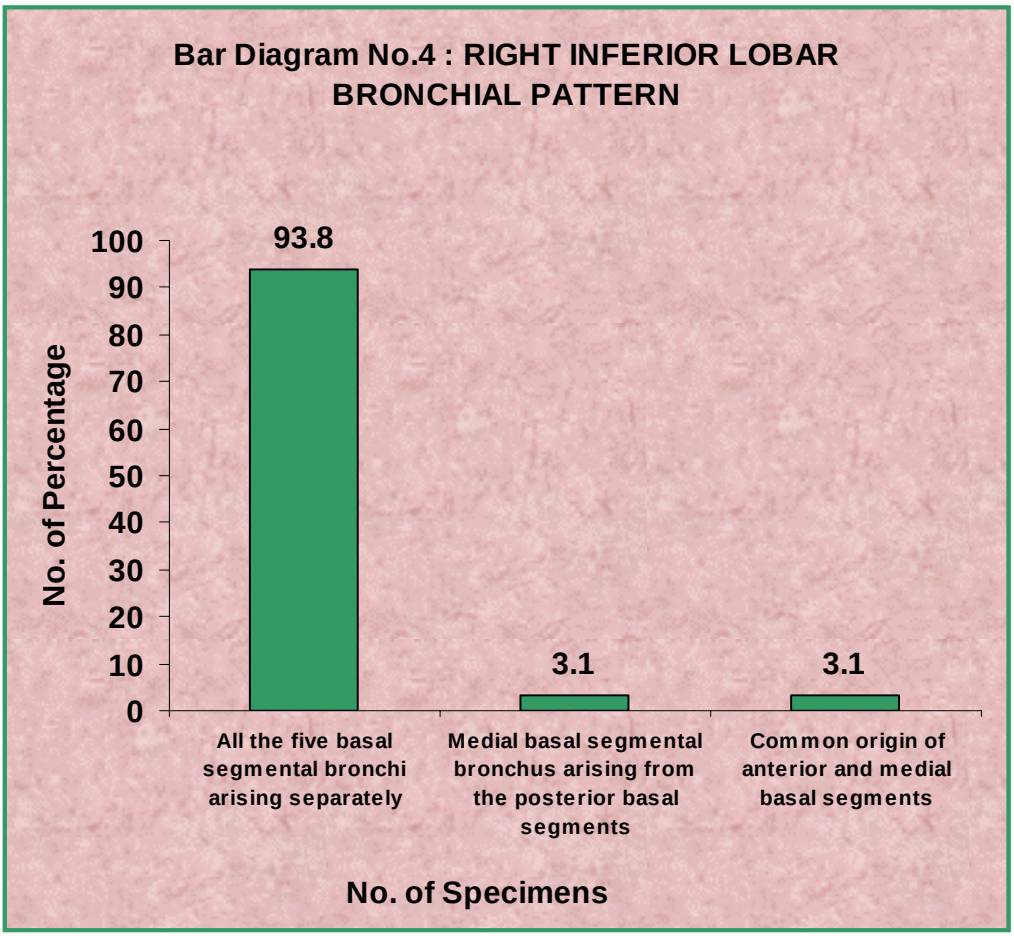


TABLE No - 10

LEFT UPPER LOBAR BRONCHIAL PATTERN

Sl. No.	Segmental Variation	No. of specimens	Percentage
01.	Normal pattern	28	87.5
02.	Absence of lingular bronchus from superior lobar bronchus	2	6.3
03.	Common stem for anterior and posterior segmental bronchi	1	3.1
04.	Absence of all the segmental bronchi from superior lobar bronchus	1	3.1

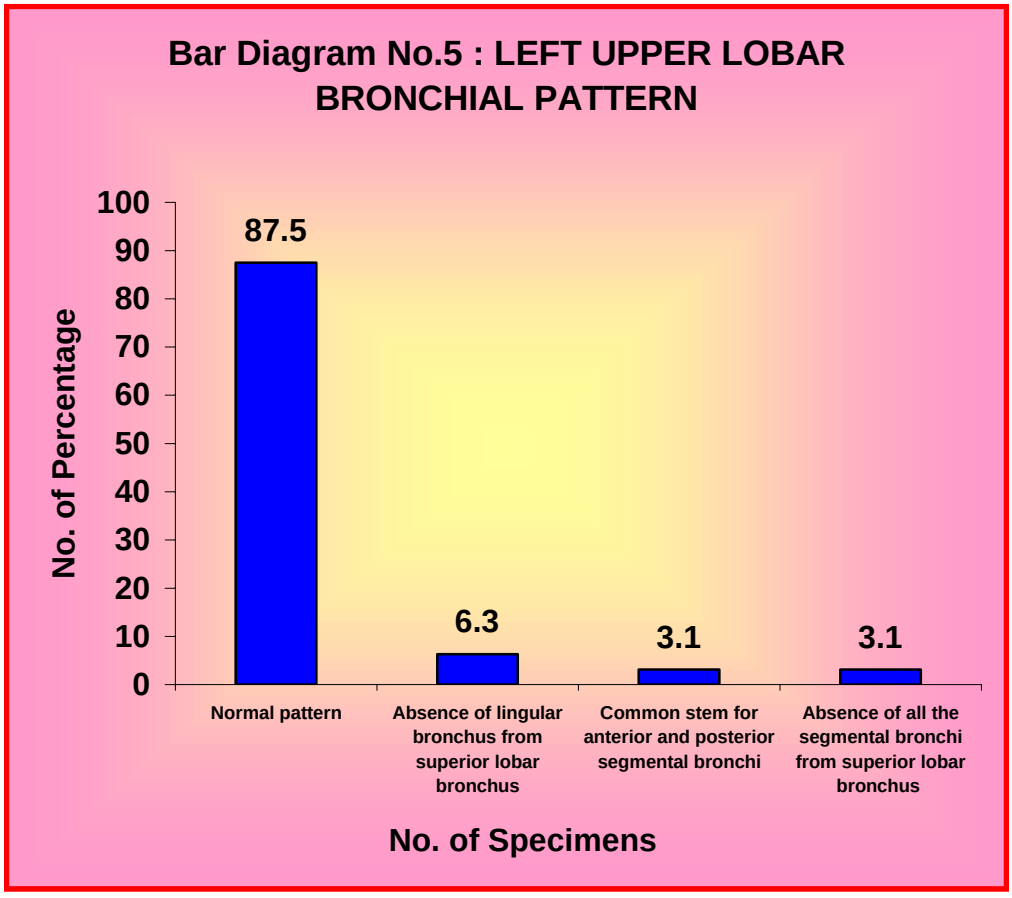


TABLE - No - 11

LEFT LOWER LOBE SEGMENTAL PATTERN

Sl. No.	Segmental Variation	Number	Percentage
01.	Normal pattern	27	84.4
02.	Absence of all the segmental bronchi from the inferior lobar bronchus	1	3.1
03.	Absence of medial basal segmental bronchus	1	3.1
04.	Lateral basal segmental bronchus arising from the inferior lobar bronchus	1	3.1
05.	Lingular bronchus arising from inferior lobar bronchus	2	6.3

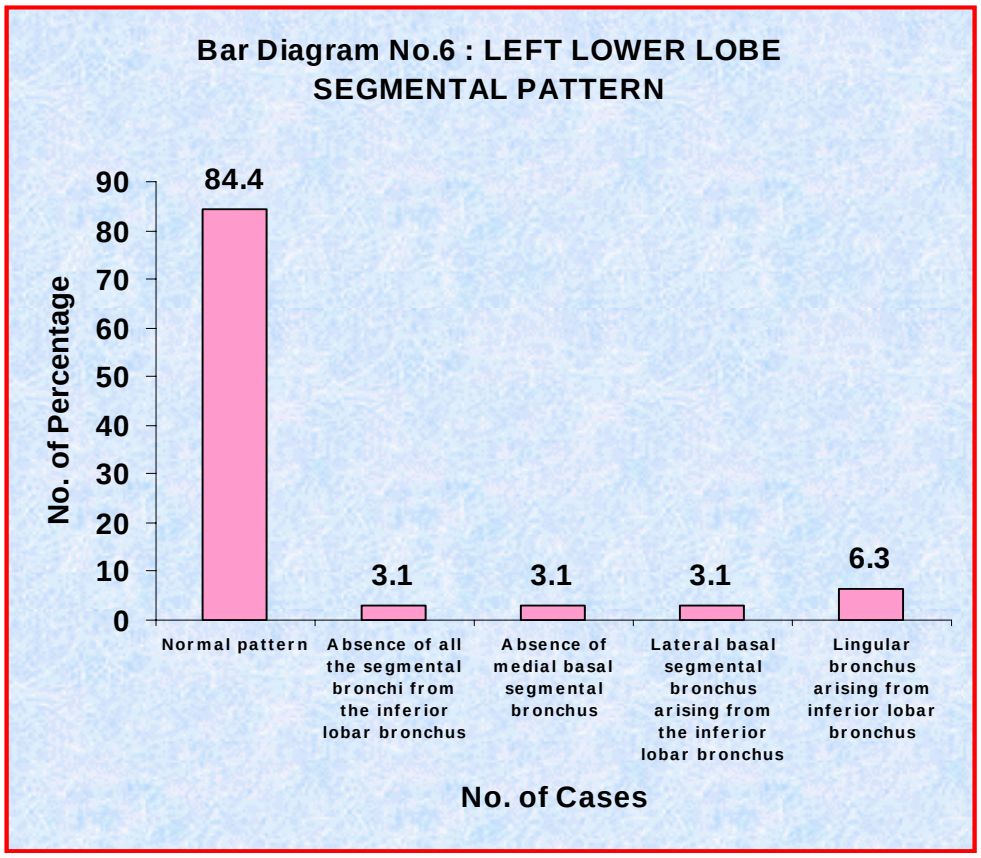


TABLE No - 12

V. NUMBER OF SEGMENTS IN EACH LUNG

Sl.No.	Right Lung	Left Lung	S.No.	Right Lung	Left Lung
01.	10	10	17.	10	10
02.	10	10	18.	10+1	10
03.	10	10	19.	10+1	10
04.	10	10	20.	10	10
05.	10	10	21.	10	10
06.	10	10	22.	10	10
07.	10	10	23.	10	10
08.	10	10	24.	10	10
09.	10	10	25.	10	10
10.	11	10	26.	10	10
11.	10	10	27.	10	09
12.	10+1	10	28.	10	10
13.	10	10	29.	10	10
14.	10	10	30.	10	10
15.	10	00	31.	10	10
16.	10	10	32.	10	10

N.B. In 10+1, +1 indicates the sub-superior segmental bronchus.

TABLE No - 12(a)

RIGHT LUNG

S.No.	Number of Segments Present	Number of Specimens	Percentage
01.	11	1	3.1
02.	10+1	3	9.4
03.	10	28	87.5

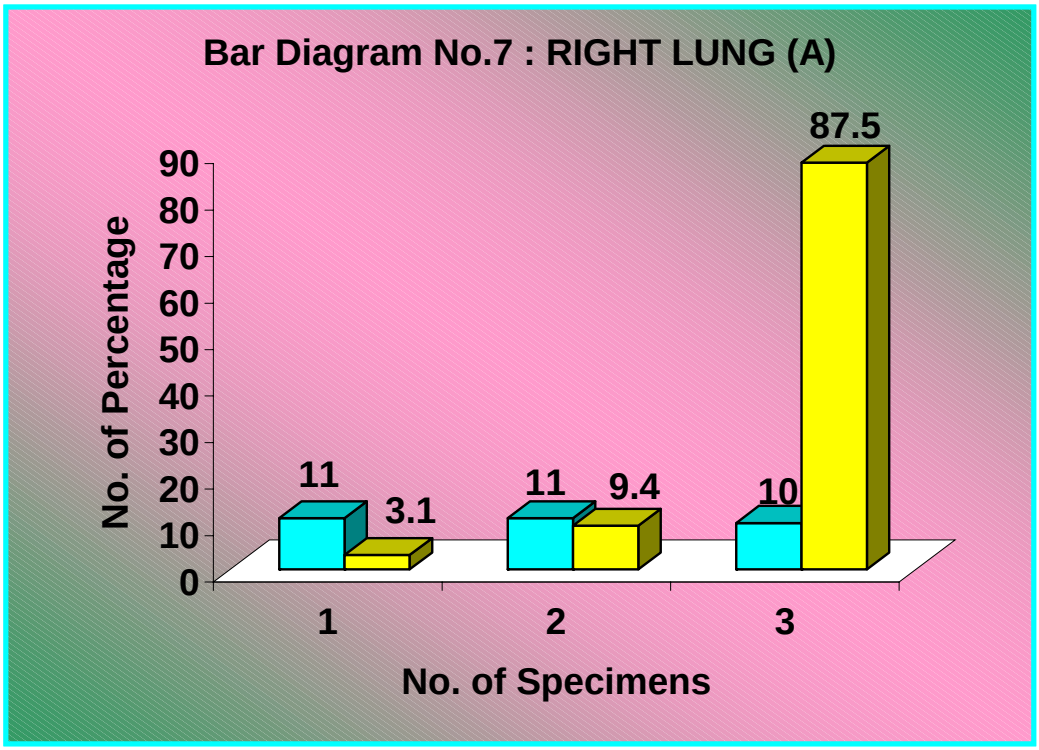


TABLE No - 12(b)

LEFT LUNG

S.No.	Number of Segments Present	Number of Specimens	Percentage
01.	10	30	93.8
02.	09	1	3.1
03.	00	1	03.1

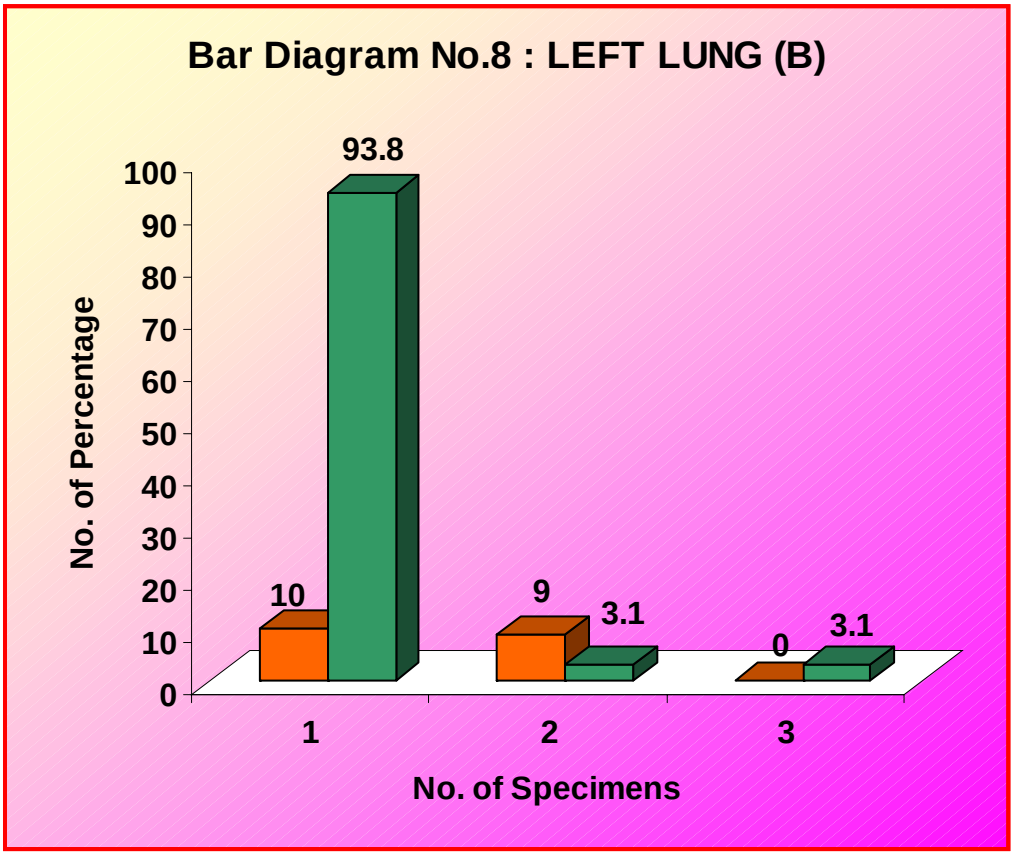


TABLE No.14

INCOMPLETE FISSURE RIGHT LUNG

Authors	Percentage	
	Major Fissure	**Minor Fissure**
Dandy W.E. Jr.,	12.5% to 73%	60% to 90%
Present Study	___	09.4%

TABLE No - 15

HORIZONTAL FISSURE LEFT LUNG

Name of the Scientists	Percentage
Austin J.H.	8 - 18
Boyden E.A.	8
Gray	10
Present Study	06.3

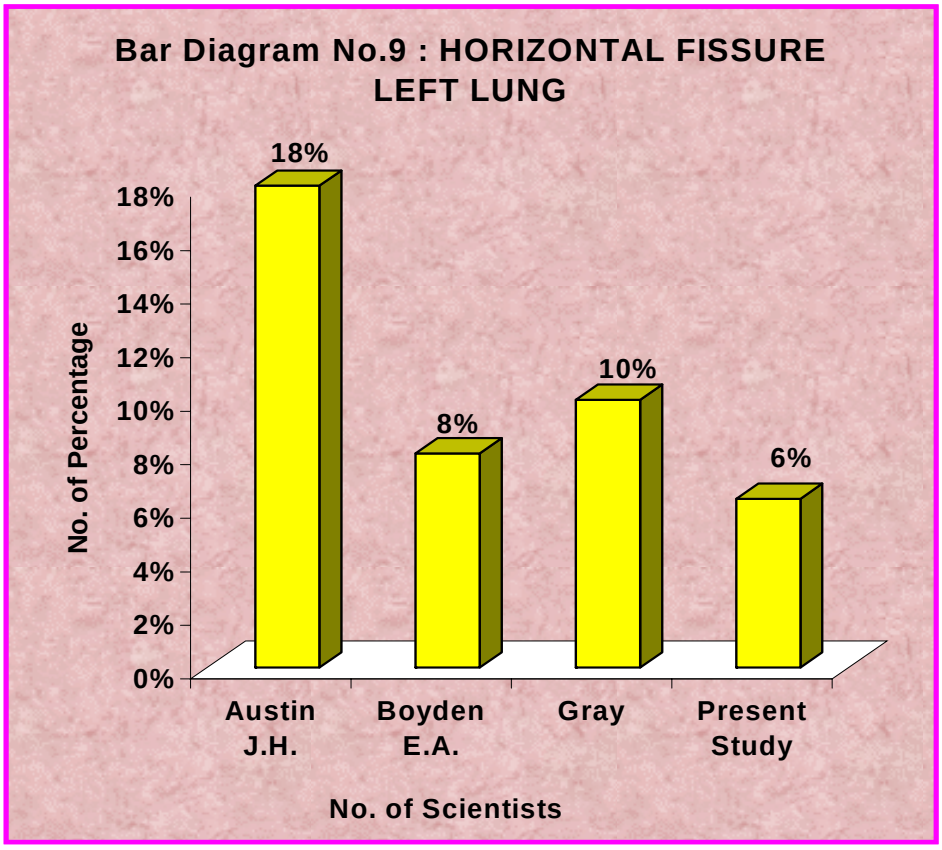


TABLE No - 16

TRIFURCATION - RIGHT UPPER LOBAR BRONCHUS

Sl.No.	Authors	Percentage
01.	Boyden and Scannell	46%
02.	Bloomer, Liebow and Hales	52%
03.	Present study	68.71%

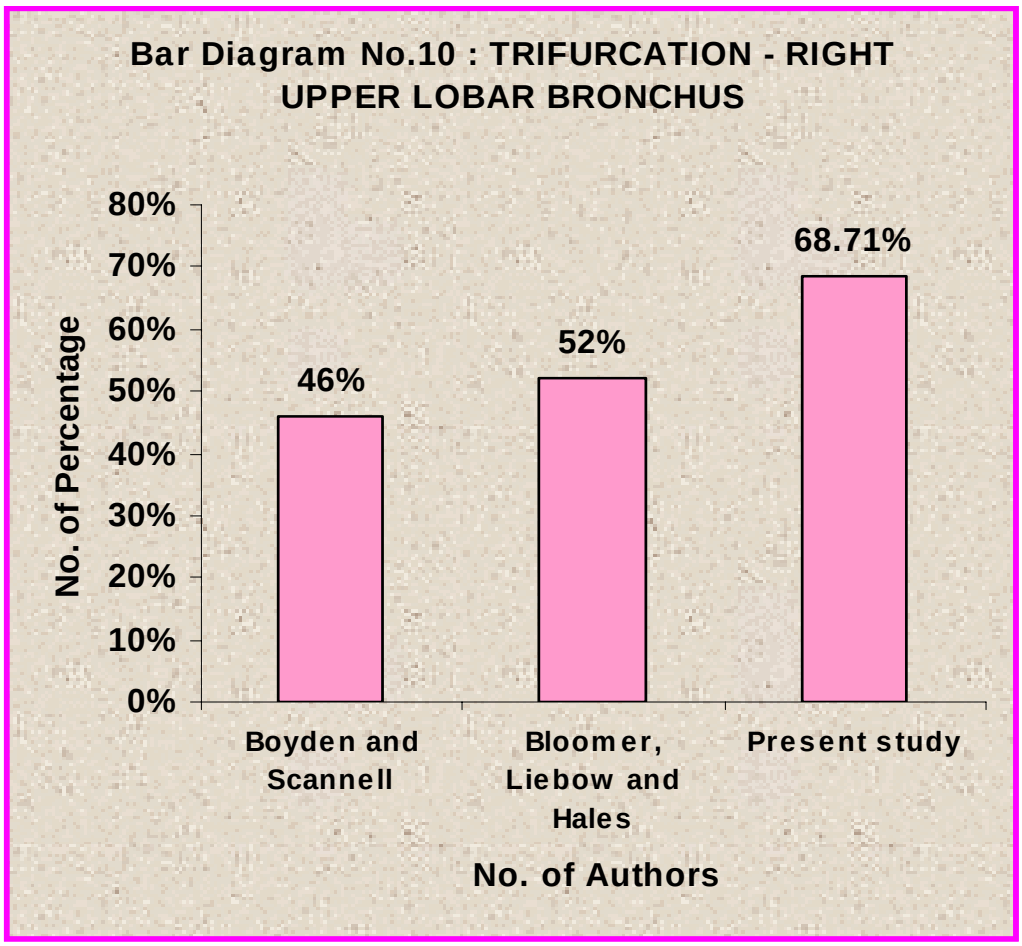


TABLE No - 17

TRIFURCATION OF RIGHT MIDDLE LOBAR BRONCHUS

Sl.No.	Authors	Percentage
01.	Boyden and Hamre	2-3%
02.	Present study	6.3%

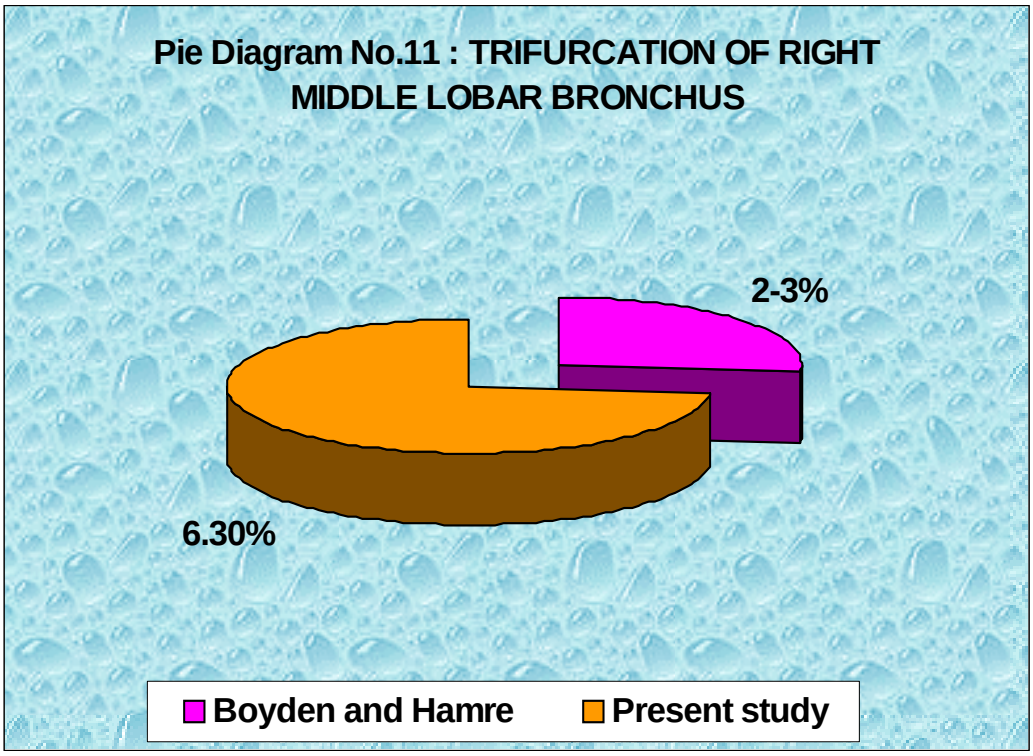
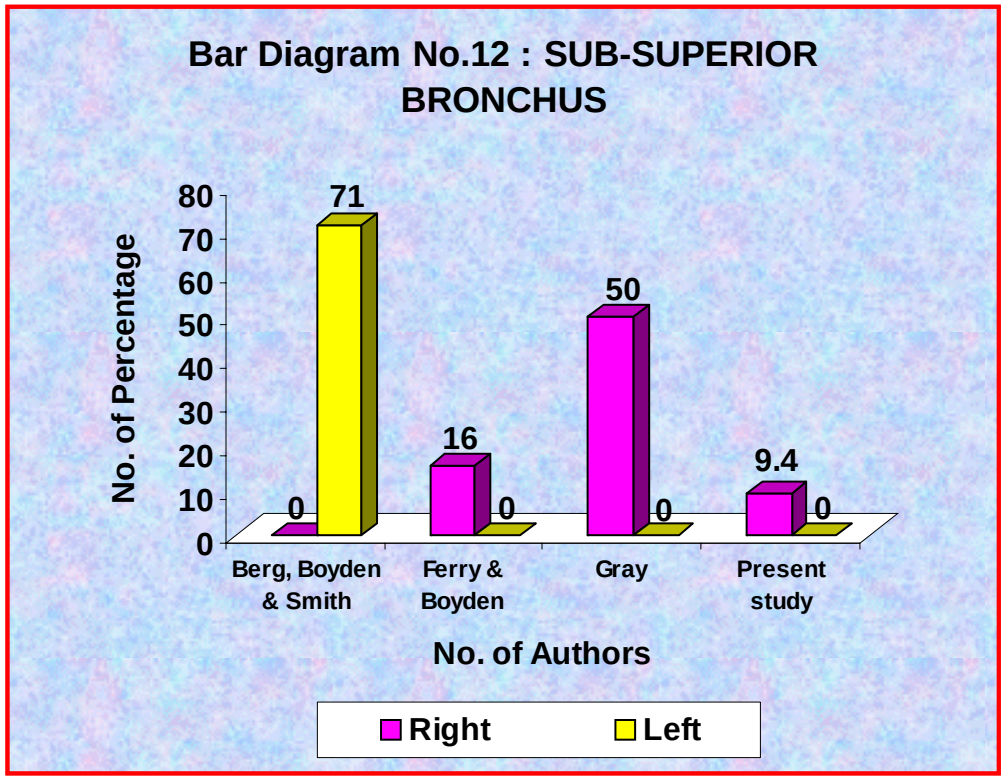
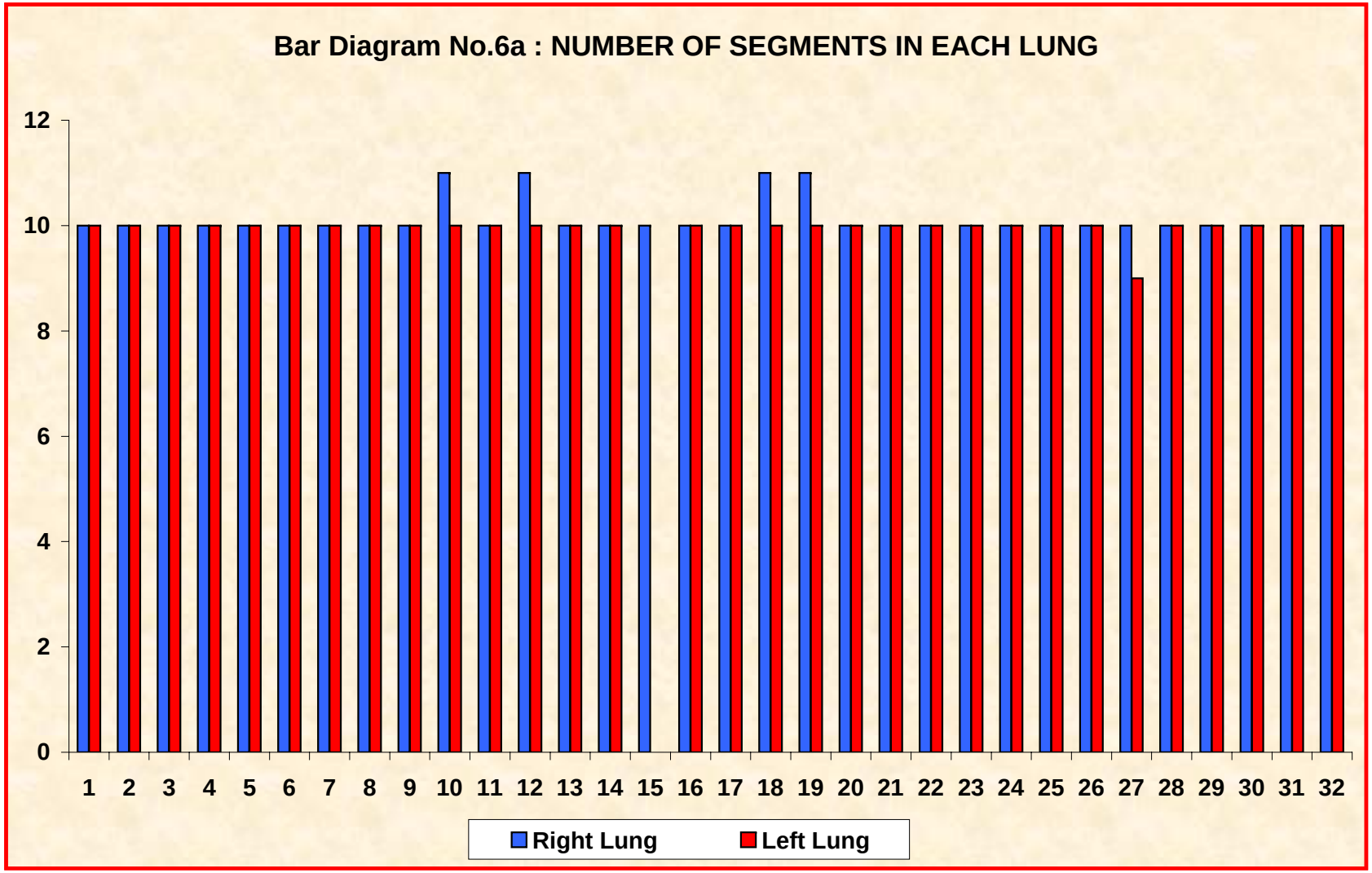


TABLE No - 18

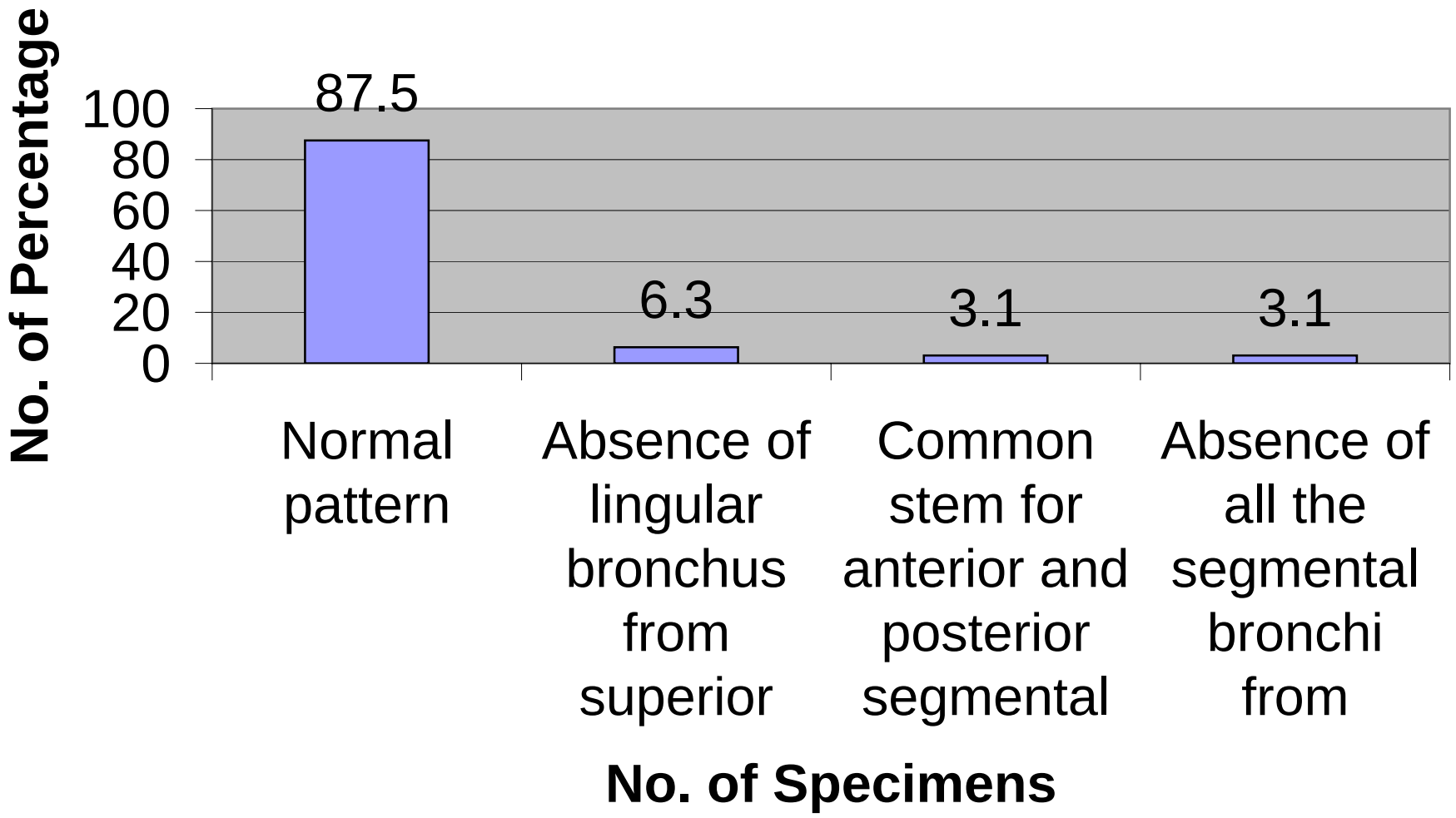
SUB-SUPERIOR BRONCHUS

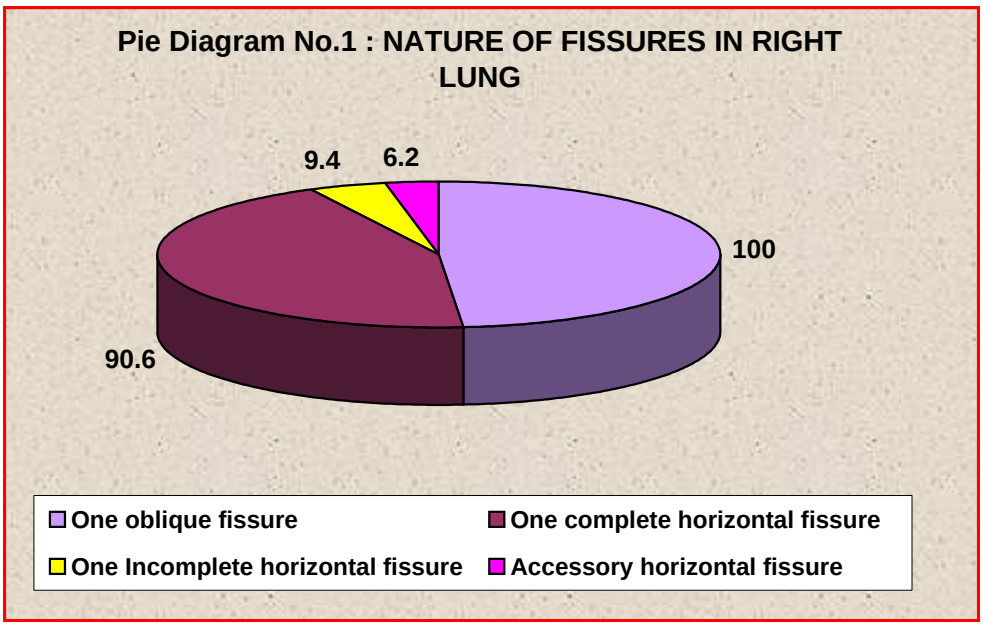
Sl.No.	Authors	Percentage	
		Right	Left
01.	Berg, Boyden & Smith	-	71
02.	Ferry & Boyden	16	-
03.	Gray	>50	-
04.	Present study	9.4	-

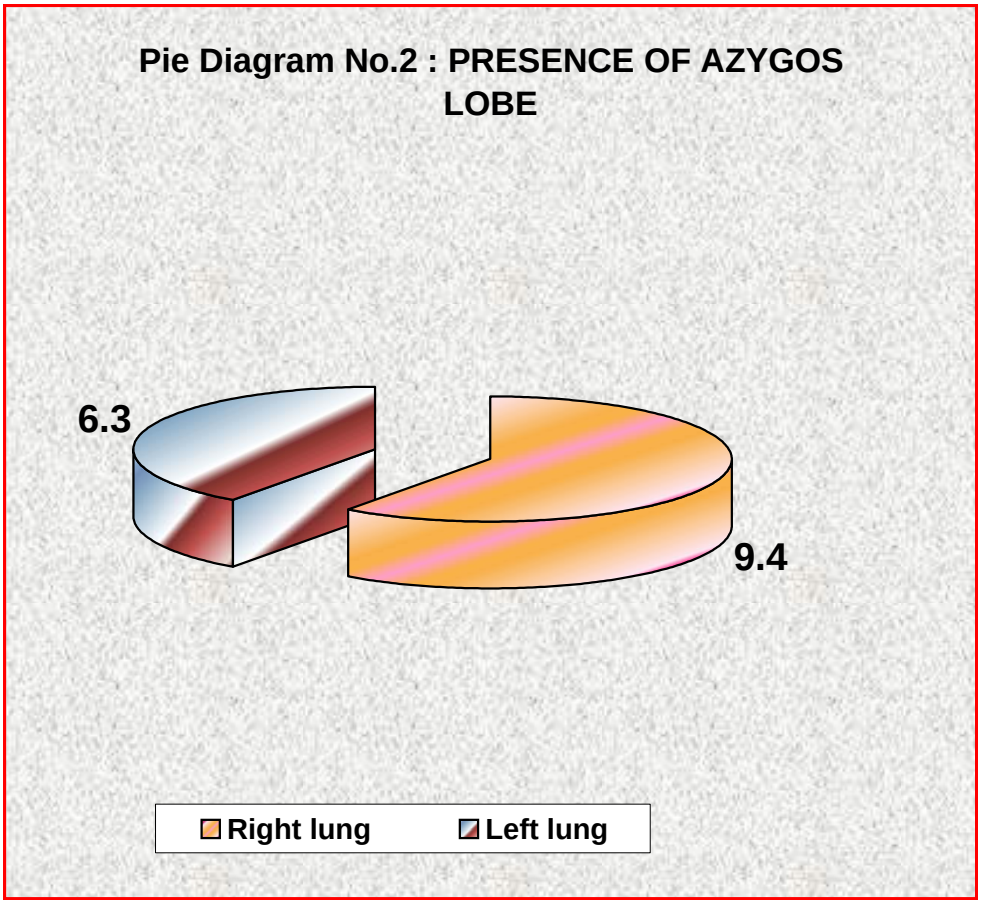


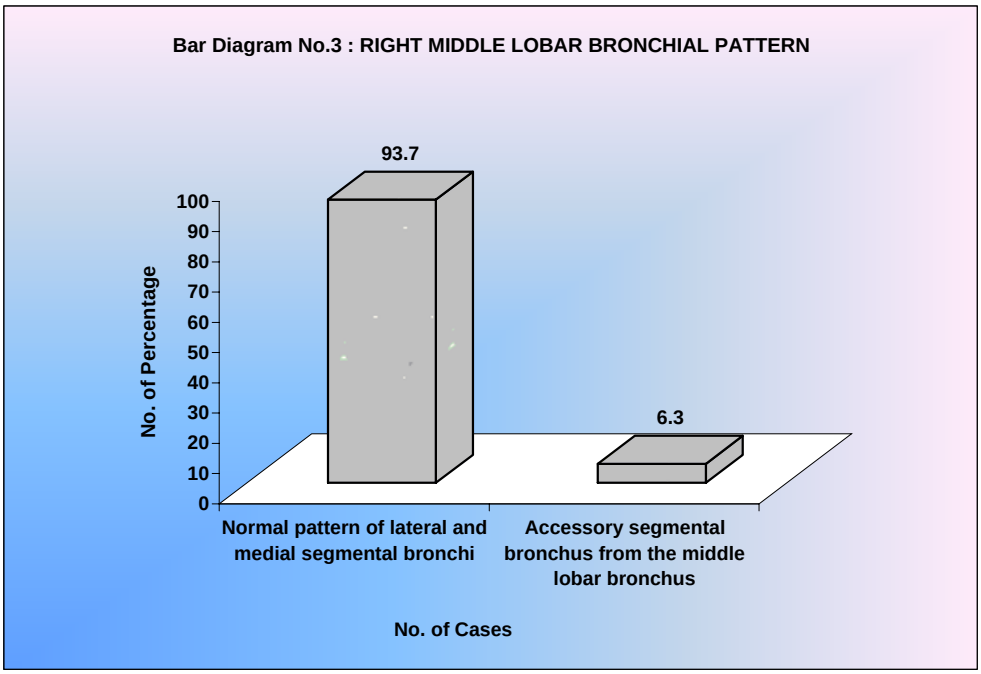

Bar Diagram No.6a : NUMBER OF SEGMENTS IN EACH LUNG
12
10
8
6
4
2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
Right Lung
Left Lung

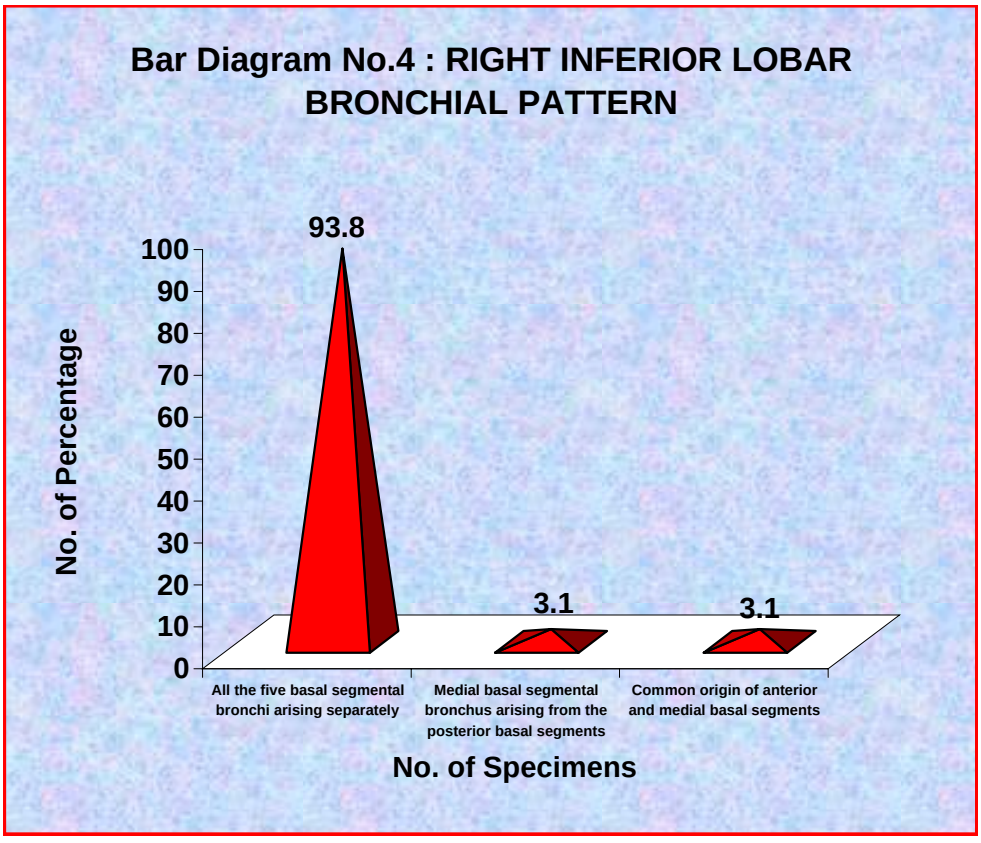
Bar Diagram No.5 : LEFT UPPER LOBAR BRONCHIAL PATTERN



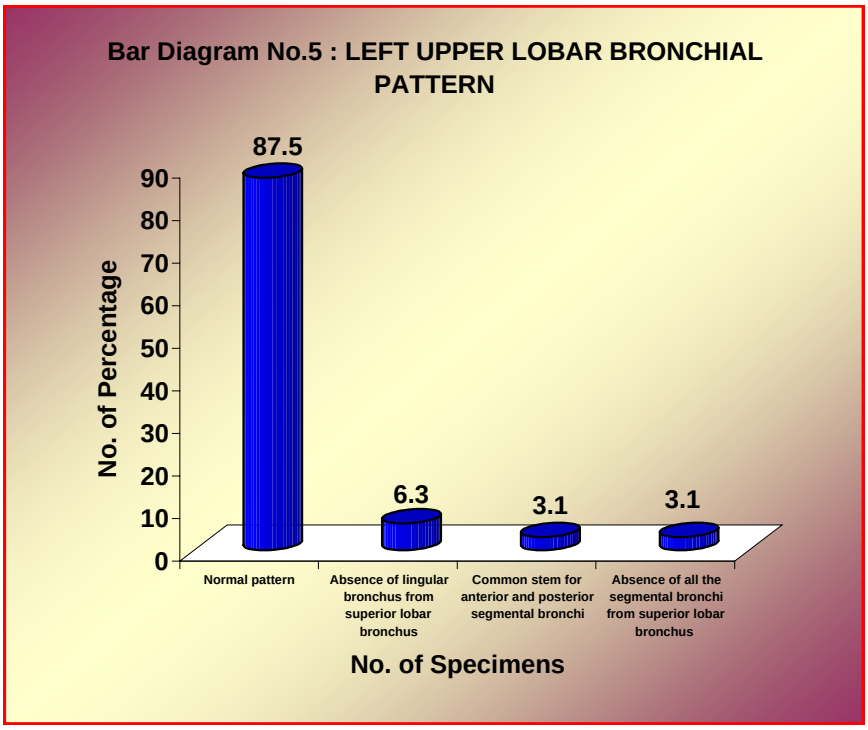

Pie Diagram No.1 : NATURE OF FISSURES IN RIGHT LUNG
9.4
6.2
100
90.6
One oblique fissure
One complete horizontal fissure
One Incomplete horizontal fissure
Accessory horizontal fissure

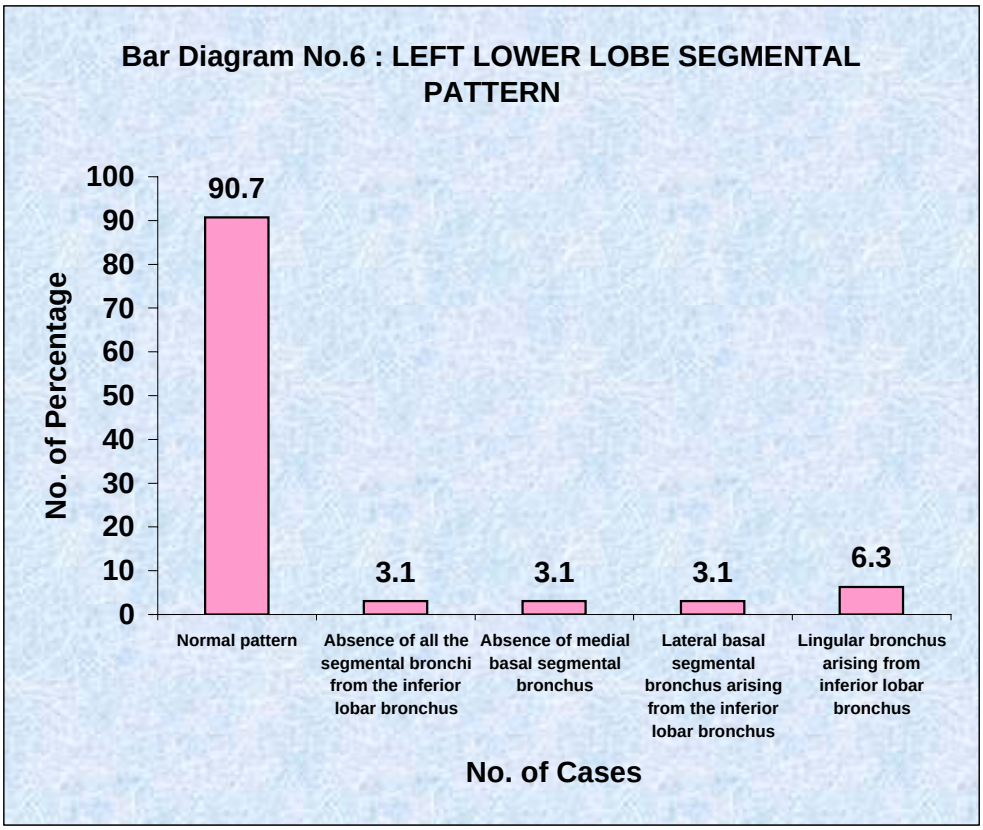

Pie Diagram No.2 : PRESENCE OF AZYGOS LOBE
6.3
9.4
Right lung
Left lung

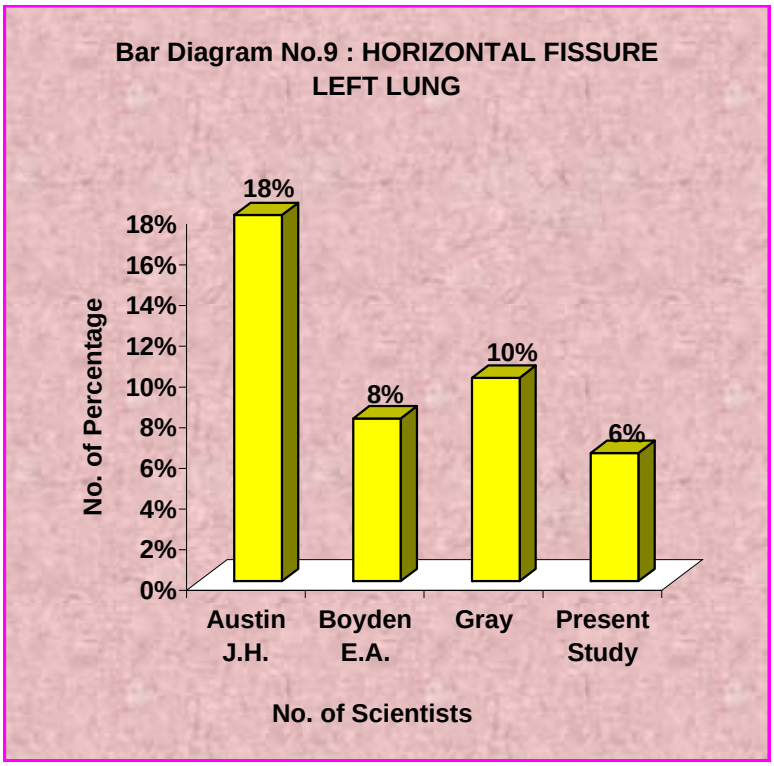


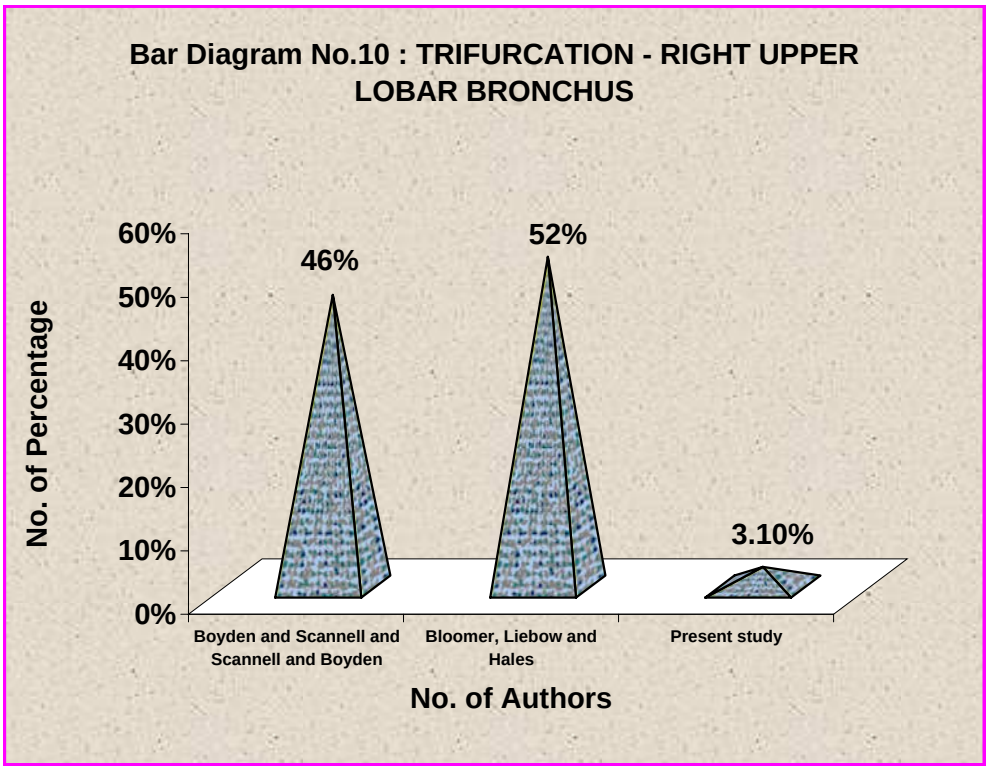


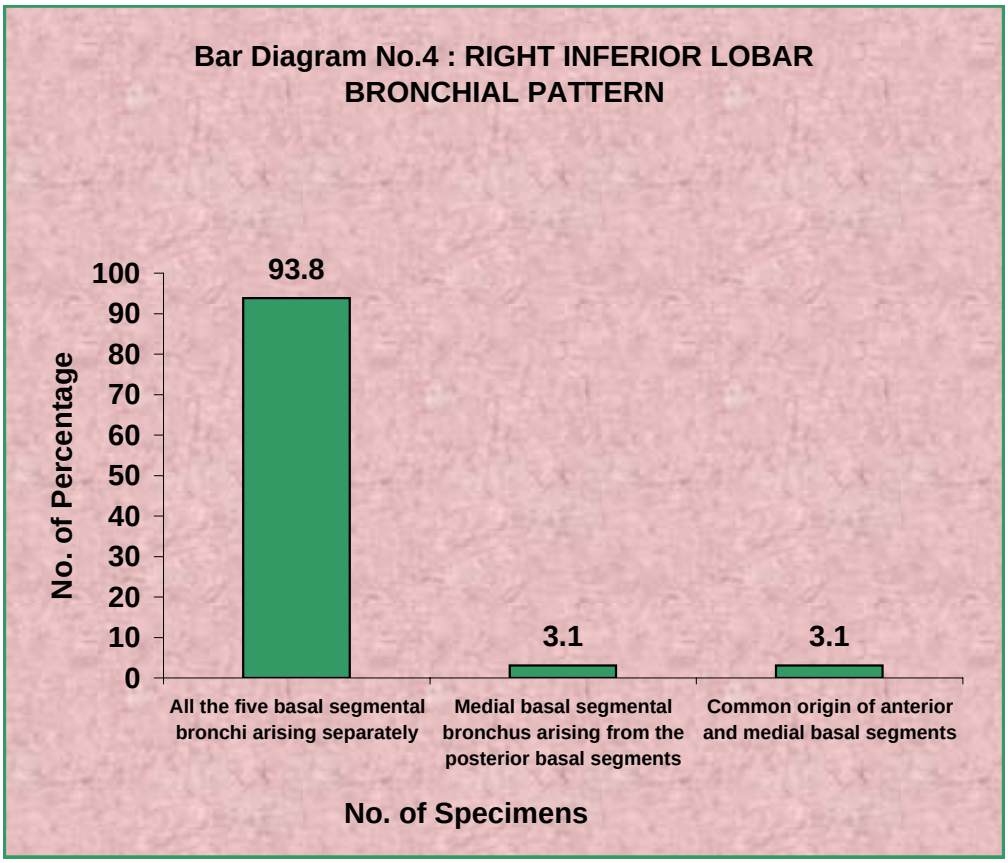
Bar Diagram No.5 : LEFT UPPER LOBAR BRONCHIAL

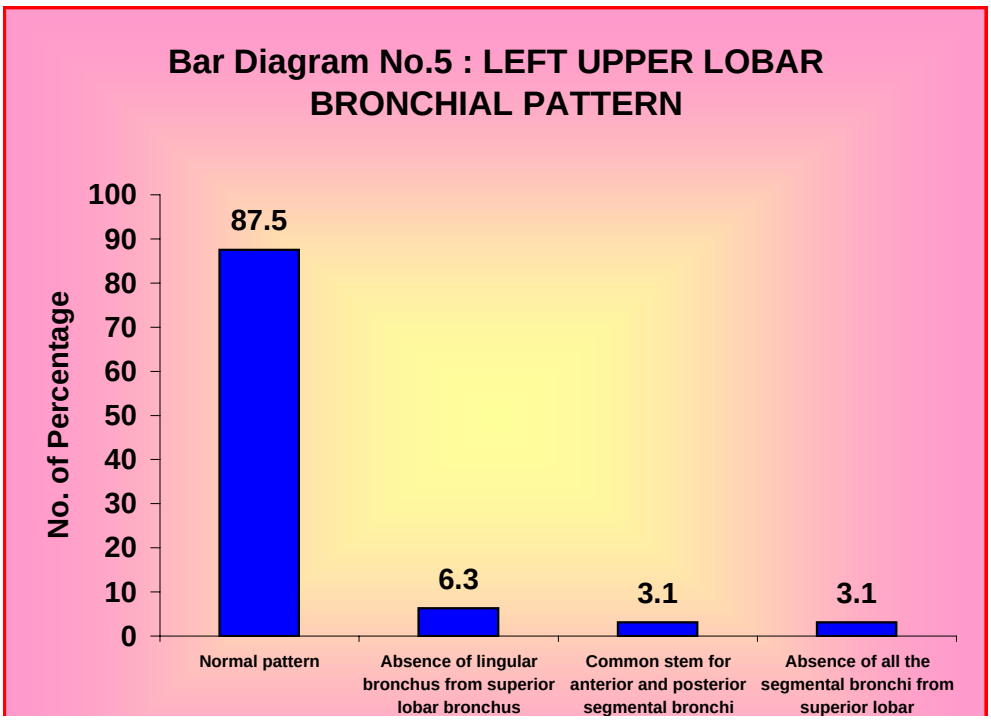

Bar Diagram No.5 : LEFT UPPER LOBAR BRONCHIAL PATTERN
No. of Percentage
90
80
70
60
50
40
30
20
10
0
87.5
6.3
3.1
3.1
Normal pattern
Absence of lingular bronchus from superior lobar bronchus
Common stem for anterior and posterior segmental bronchi
Absence of all the segmental bronchi from superior lobar bronchus
No. of Specimens


Bar Diagram No.6 : LEFT LOWER LOBE SEGMENTAL PATTERN
No. of Percentage
100
90
80
70
60
50
40
30
20
10
0
90.7
3.1
3.1
3.1
6.3
Normal pattern
Absence of all the segmental bronchi from the inferior lobar bronchus
Absence of medial basal segmental bronchus
Lateral basal segmental bronchus arising from the inferior lobar bronchus
Lingular bronchus arising from inferior lobar bronchus
No. of Cases


Bar Diagram No.9 : HORIZONTAL FISSURE LEFT LUNG
No. of Percentage
18%
16%
14%
12%
10%
8%
6%
4%
2%
0%
18%
8%
10%
6%
Austin J.H.
Boyden E.A.
Gray
Present Study
No. of Scientists


Bar Diagram No.10 : TRIFURCATION - RIGHT UPPER LOBAR BRONCHUS
No. of Percentage
60%
50%
40%
30%
20%
10%
0%
46%
52%
3.10%
Boyden and Scannell and Scannell and Boyden
Bloomer, Liebow and Hales
Present study
No. of Authors


Bar Diagram No.4 : RIGHT INFERIOR LOBAR BRONCHIAL PATTERN
No. of Percentage
100
90
80
70
60
50
40
30
20
10
0
93.8
3.1
3.1
All the five basal segmental bronchi arising separately
Medial basal segmental bronchus arising from the posterior basal segments
Common origin of anterior and medial basal segments
No. of Specimens


Bar Diagram No.5 : LEFT UPPER LOBAR BRONCHIAL PATTERN
No. of Percentage
100
90
80
70
60
50
40
30
20
10
0
87.5
6.3
3.1
3.1
Normal pattern
Absence of lingular bronchus from superior lobar bronchus
Common stem for anterior and posterior segmental bronchi
Absence of all the segmental bronchi from superior lobar

	Normal pattern	Absence of lingular bronchus from superior lobar bronchus	Common stem for anterior and posterior segmental bronchi	Absence of all the segmental bronchi from superior lobar bronchus
No. of Specimens				